SCIENCE

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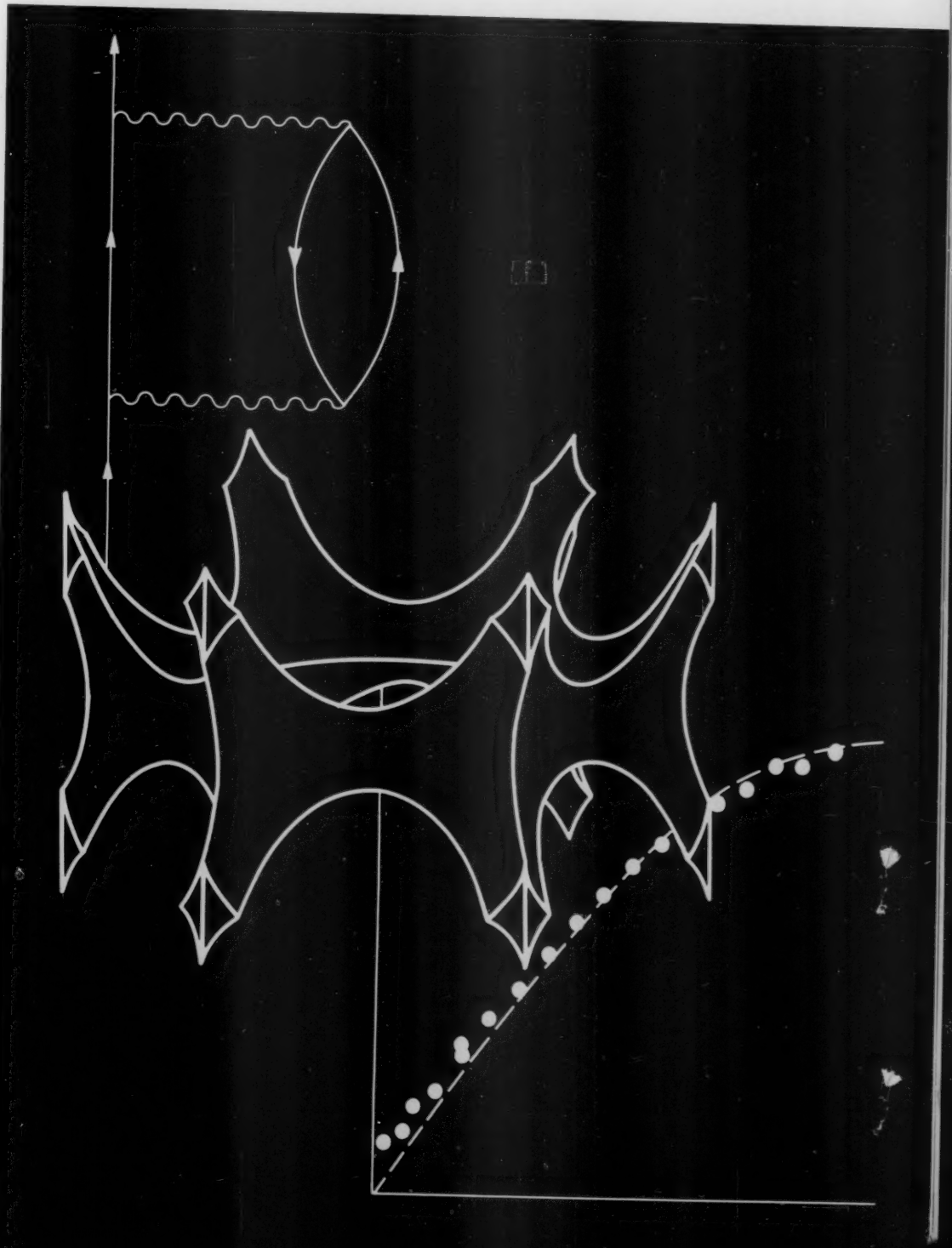

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Cover Feynam diagram, representing the fundamental theory of electron gases (upper left). A Fermi surface derived from more detailed, but much less fundamental theory (center). Comparison of the detailed theory with experimental measurements (lower right). See page 915. [*The Fermi Surface*, W. A. Harrison and M. B. Webb, Eds. (Wiley, New York, 1960)]

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2. The 29th John Wesley Powell Memorial Lecture. Speaker: Glenn T. Seaborg; Paul M. Gross, presiding.
3. On "AAAS Day," the four broad, interdisciplinary symposia—Physics of the Upper Atmosphere; Geochemical Evolution—The First Five Billion Years; Existing Levels of Radioactivity in Man and His Environment; and Water and Climate—arranged by AAAS Sections jointly.
4. The Special Sessions: AAAS Presidential Address and Reception; Joint Address of Sigma Xi and Phi Beta Kappa by Harrison Brown; the Tau Beta Pi Address; National Geographic Society Illustrated Lecture; and the second George Sarton Memorial Lecture.
5. The programs of all 18 AAAS Sections (specialized symposia and contributed papers).
6. The programs of the national meetings of the American Astronomical Society, American Society of Criminology, American Nature Study Society, American Society of Naturalists, American Society of Zoologists, Beta Beta Beta Biological Society, Biometric Society (WNAR), National Association of Biology Teachers, Scientific Research Society of America, Society for General Systems Research, Society of Protozoologists, Society of Systematic Zoology, and the Society of the Sigma Xi.
7. The multi-sessioned special programs of the American Association of Clinical Chemists, American Astronautical Society, American Meteorological Society, American Physiological Society, American Psychiatric Association, Association of American Geographers, Ecological Society of America, National Science Teachers Association, National Speleological Society—and still others, a total of some 70 to 80 participating organizations.
8. The sessions of the Academy Conference, the Conference on Scientific Communication, and the Conference on Scientific Manpower.
9. The sessions of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, of the AAAS Committee on Science in the Promotion of Human Welfare.
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Letters

Sensory Deprivation

In their article, "Sensory deprivation and hallucinations" [*Science* **133**, 1808 (1961)], Vernon, Marton, and Peterson attribute the beginnings of such research to the 1954 McGill studies. It should be noted that hallucinations resulting from the use of shaped ping-pong balls to achieve diffuse, homogeneous illumination were reported by Hochberg, Triebel, and Seamon [*J. Exptl. Psychol.* **41**, 153 (1951)], and reprinted in Beardslee and Wertheimer, Eds., *Readings in Perception* (Van Nostrand, Princeton, N.J., 1958), pp. 61–69: "Color adaptation under conditions of homogeneous visual stimulation (*Ganzfeld*)." This paper described investigations undertaken to measure the fading and blink-restored recovery of the illuminating color, which apparently surprised Vernon *et al.* The occurrence of some form of hallucinatory experience for 5 out of 11 subjects was described as an incidental phenomenon.

As pointed out in that paper, it is necessary to paste back the subjects' eyelashes in order to achieve a homogeneous visual field. If Vernon *et al.* had taken that precaution they might have gotten more frequent reports of hallucinations.

HOWARD E. GRUBER
Department of Psychology, University of Colorado, Boulder

We greatly appreciate the interest Gruber has shown in our work. He is quite correct in relating the technique of homogeneous visual stimulation to Hochberg *et al.*, and it was obviously their technique which we tried to copy. That is, we copied most of their technique; we did not paste the upper eyelashes to the upper eyelids, for several reasons. In the first place, we found it easily possible to so fit the eyecaps that the eyelashes did not hit them; we also found that eyelashes did not prevent the achievement of a homogeneous visual field for any of our subjects; and finally, we felt that to paste the eyelashes back for a 48-hour period would lead to unnecessary subject discomfort.

Gruber states that Hochberg *et al.* found recovery of the illuminating color resulting from blinking. This is precisely what they *did not* find. Instead they report: ". . . brief blinking during and after adaptation had no apparent effects. . . ." They did find, however, a brief restoration of the illuminating color in five of ten subjects following deliberate left-right eye movements. But they attach little importance to that finding, since, in the absence of a fixation point, eye movements must have continuously occurred.

JACK A. VERNON
Department of Psychology, Princeton University, Princeton, New Jersey

Alpha Blocking

Aside from a certain querulous tone, I can find little to object to in the report by Stern *et al.* [*Science* **134**, 388 (11 Aug. 1961)] commenting on an earlier report by Wolff and me on a study of cerebral function [*ibid.* **131**, 1617 (1960)]. On close reading of both communications, the observations of Stern *et al.* seem to cast doubt primarily in our somewhat parsimonious interpretation of our original findings. Stern and his associates merely replicate the question originally asked long ago by Knott and Henry as to whether or not the alpha blocking to sound before the appearance of light when the two are paired really constitutes a conditioned reflex. In the second paragraph of our report we stated: "Such a phenomenon has been known as a temporary cerebral connection or a conditioned cerebral response (it being understood that the phenomenon does not fulfill the criteria for Pavlovian conditioning)."

We have been engaged in studying the presence or absence of this phenomenon in health and disease, but have not been concerned with the interpretation of the phenomenon either as a "conditioned reflex" or as an "adaptation to a complex stimulus." The term *conditioned cerebral response* has for some years been commonly used by neurophysiologists studying this phenomenon and is understood by those familiar with the field to imply a phenomenon which is different from Pavlovian conditioning, whether or not it implies "adaptation to a complex stimulus." The term was thus used by us because of its common acceptance by investigators in this field, and it was clearly stated not to imply classic Pavlovian conditioning.

CHARLES E. WELLS
School of Medicine, Vanderbilt University, Nashville, Tennessee

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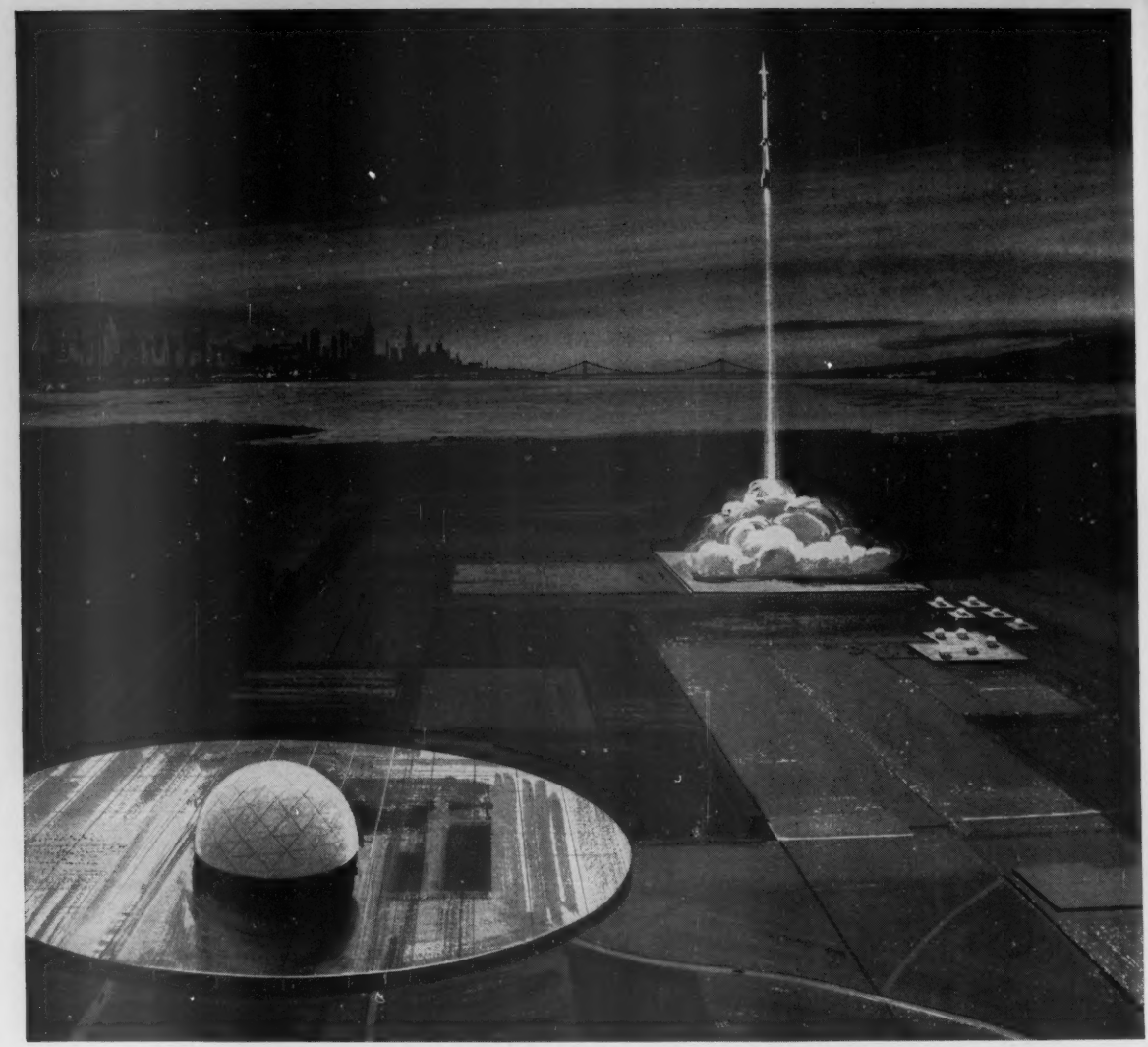

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SCIENCE

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Tricks with Numbers

Most people know that it is a fallacy to compare absolute numbers instead of rates or percentages. The fact that California annually leads the nation in motor vehicle deaths does not necessarily mean that it is the most dangerous state to drive in. Nevada, for example, with a much lower absolute number, usually leads the nation in motor vehicle deaths per hundred thousand population. Thus, in 1958, this rate for Nevada was 43 and for California, 26.

In one field of practical concern, that of consumer credit, the customer usually has no way to determine what his true credit rates are and no standard by which to compare different schemes. Consider a one-year loan that is to be paid back in monthly installments. One method is the "add-on" plan. The borrower signs a note for $105 and receives $100. The true annual interest rate on the declining balance is 9.10 percent, not 5 percent. Then there is the "discount" plan. The borrower signs a note for $100 and receives $95; this makes his annual interest rate 9.58 percent. But rates as low and as relatively straightforward as these are unusual. To take an actual case, a man signed a note for $114 to obtain a $100 loan. The charges were: interest and discount, $6.93; investigation fee, $2.00; insurance fee, $2.00; bank service fee, $2.78. On an annual basis he was paying at the rate of 24.8 percent. Another plan is to determine interest on declining balances. This plan is used by credit unions and many "small loan" companies, but rarely by banks. The customer knows that his money costs him 1 percent or more per month, and he can readily compute his annual rate by multiplying by 12.

The practices are far more diverse in installment buying than they are for personal loans. The rates vary with number of installments and length of loan, with service and insurance charges, and with differences between cash price and credit price. The ordinary customer simply cannot compute the rate he is paying for his credit. Interest charges range from about 12 percent to well over 100 percent in extreme cases, but the true rates are not ordinarily disclosed.

To remedy this lack of standardization, Senator Douglas and 21 of his colleagues have introduced a "Truth in Lending Act" (S. 1740), which is now in committee. The main feature of the bill is the requirement that the percentage that the finance charge bears to the total amount to be financed be expressed as "a simple annual rate on the unpaid balance of the obligation" (as is now done on many, but not all, personal loans and rarely if ever on installment credit).

The bill is opposed by the following, among others: The American Bankers Association, the Chamber of Commerce of the United States, and the National Retail Furniture Association. It is favored by the Federal Reserve System, the AFL-CIO, the President's Council of Economic Advisers, and the Credit Union National Association, to name a few. Opponents of the bill argue that it invades states' rights, that it is unnecessary, that if passed it would be detrimental to the economy, and that simple interest would be too difficult to calculate. Those who favor it deny that any of these arguments have validity. On the positive side they point to the benefit that would accrue to the customer if he could shop for credit as he can for goods. The statement of the simple annual interest rate would permit a customer to compare the true costs of different forms of credit and to act rationally on that basis. On balance, we favor any step that encourages rational decisions.—G.DuS.

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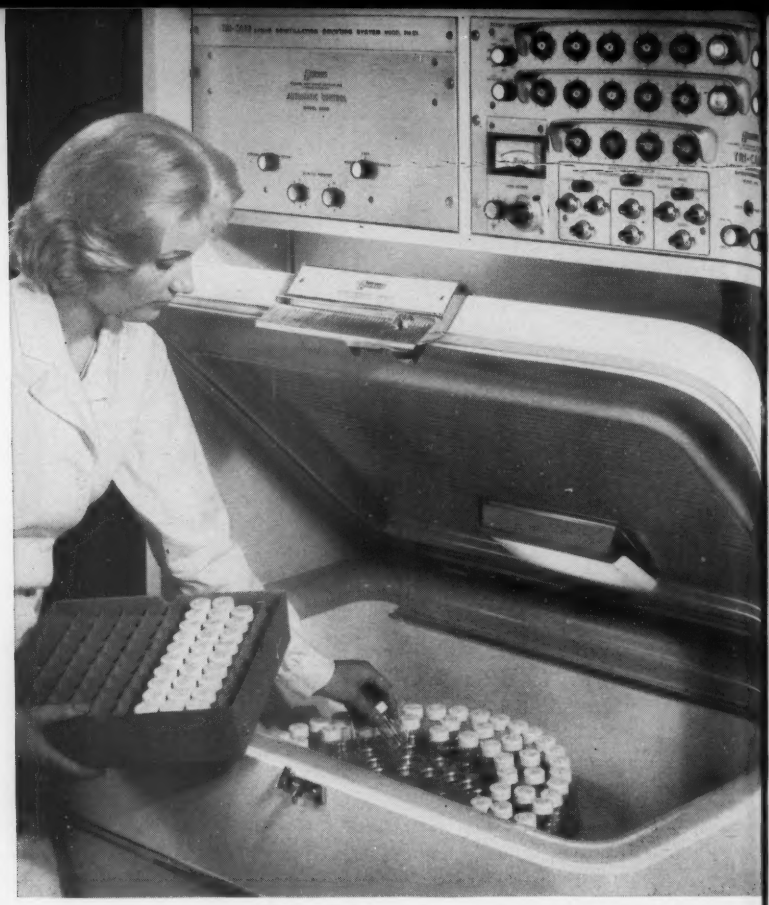

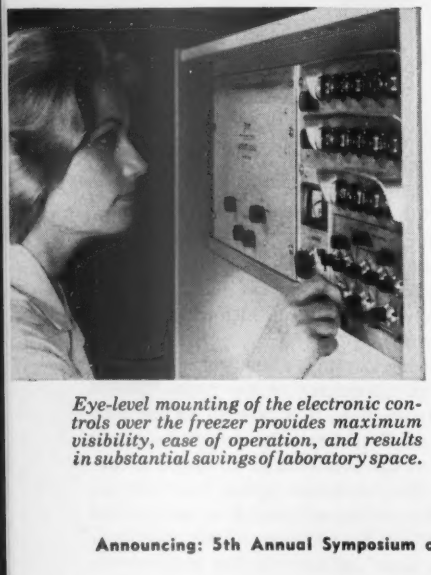

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29 September 1961, Volume 134, Number 3483 SCIENCE

CURRENT PROBLEMS IN RESEARCH

The Fermi Surface

These geometrical surfaces represent the complex gyrations executed by electrons in ordinary metals.

Walter A. Harrison

The properties we generally associate with metals result from the ability of electrons to run freely through them. These electrons are responsible for easy conduction of heat and electricity, produce the shiny appearance, and act as the glue which holds the atoms together. These properties, common to all metals, have been understood in terms of mobile electrons for a long time. More subtle aspects of electronic motions, which are responsible for many of the differences among metals, have been very incompletely understood until quite recently. These subtleties are now the subject of intense investigation among solid-state physicists.

As long ago as 1900, Drude proposed that the high electrical and thermal conductivity of metals could be understood by assuming that many of the electrons in metals were free and mobile. By clarifying one property, however, he raised a paradox which was not resolvable until 1928, with the advent of quantum mechanics. If these electrons were free to move through a crystal, then they must certainly share the heat energy of a metal. They should, in fact, contribute as much to the thermal energy of a metal as the vibrating atoms themselves, a conclusion which was in direct contradiction to experimental findings. We will see how this puzzle can be resolved by using some of the concepts of quantum mechanics.

In an *isolated* atom the electrons can exist only in certain definite orbits. Only two electrons can exist in each of these orbits, and these two electrons spin in opposite directions. Ordinarily an atom has its electrons in the lowest energy orbits. This binding of the electrons close to the atomic nucleus, while giving a very low potential energy, leads to a large energy of motion, for the same reason that an earth satellite speeds up as its altitude decreases. When many atoms are brought together to form a crystal, the electrons can maintain their low potential energy while reducing their energy of motion. This happens when atoms are brought into range of the outer orbits of a neighboring atom. The electrons in these orbits are then no longer bound to a single atom but become free to move, relatively slowly, from atom to atom through the crystal. This lowers their energy of motion and, like the relaxing of a taut spring, holds the atoms together in the crystal.

In what is called "the free-electron model of metals" the metal crystal is thought of simply as a box containing electrons whose orbits are straight lines. In other words, the electrons bounce back and forth between opposite walls. It turns out that electrons can exist in only some of these orbits in the metal, just as only certain definite orbits are allowed in the atom. This restriction of the electrons to discrete orbits is a direct consequence of quantum mechanics and is really understandable only in terms of that theory. The restriction on the allowed orbits is an essential feature of our model of metals.

Just as there can be only two electrons in each orbit in the isolated atom, only two electrons may exist in each of the orbits in the metal crystal. Each of these orbits corresponds to a certain velocity.

In order to discuss which velocities the electrons take, we need a method of mapping the velocities. On an ordinary map, any position can be specified by giving its direction and distance from some central point. A similar system is convenient for mapping velocities. An orbit can be represented by a point whose direction from the center of the diagram is the direction of motion and whose distance from the origin represents speed. Thus, each point on the map corresponds to a particular velocity (Fig. 1).

Just as the surveyor draws contour lines connecting all points of the same elevation, the physicist can draw contour lines connecting all velocities corresponding to the same energy. In this case, "constant-energy" contours are circles around the central point, since an electron with a certain speed has the same energy no matter in which direction it moves. The larger the circle, the higher the speed and corresponding energy.

In a metal, with electrons moving in three dimensions, a three-dimensional velocity map is needed and the contour *line* becomes a contour *surface*. The constant-energy circle becomes a constant-energy sphere.

The Fermi Surface

Ordinarily, all the electrons have the lowest possible speeds in a metal, corresponding to the lowest energies, and each of the possible velocities corresponding to low energies can be taken by only two electrons. The constant-energy surface "surrounding" the actual velocities which electrons have in a real metal is called the Fermi surface (Fig.

The author is affiliated with the General Electric Company Research Laboratory, Schenectady, N.Y., in the Metallurgy and Ceramics Research Department.

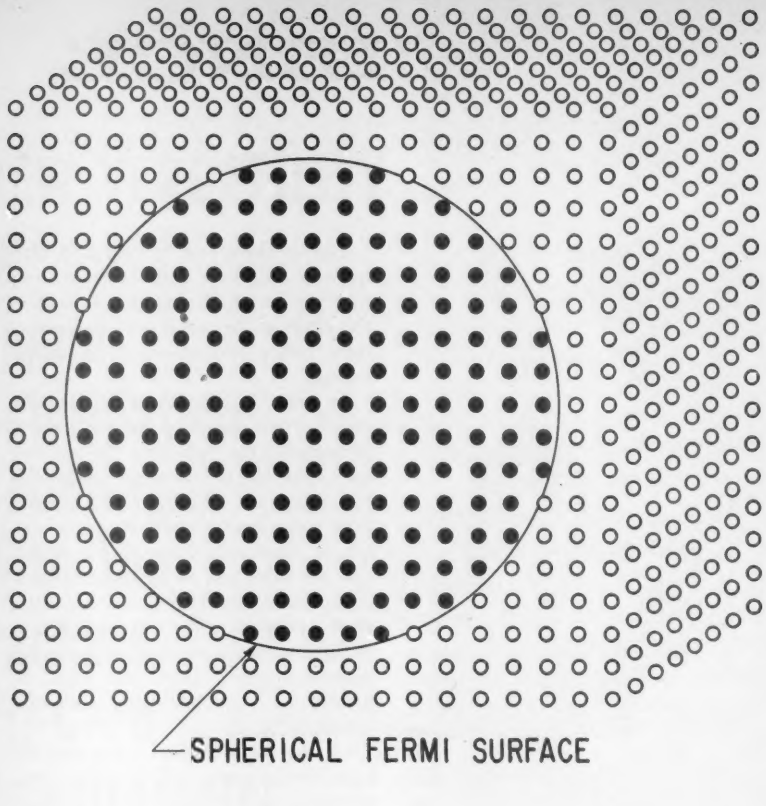


Fig. 1. Schematic diagram of possible electron velocities in a free-electron metal. Each dot corresponds to a velocity which an electron may have in the metal. The metal has two electrons with a velocity corresponding to each of the dots within a Fermi surface (solid dots) and none corresponding to dots outside (open dots). The further a dot lies from the center, the higher is the speed and energy to which it corresponds. In a real metal there may be of the order of 10^{22} dots within the Fermi surface.

1). We should emphasize again that the Fermi surface is not a real surface in real space but has meaning only in terms of our three-dimensional velocity map, just as, for example, a population growth line has meaning only on a graph showing population changes with time. The Fermi surface is a boundary surface dividing the velocities, on our map, which electrons actually have from the velocities which no electrons have.

At this point we can explain the heat-energy paradox mentioned earlier. If heat energy is added to the metal, only electrons with velocities near the Fermi surface can readily increase their energy by attaining slightly greater velocities. Electrons with lower energy cannot do this because there are *already* two electrons with each permissible neighboring velocity. It is unlikely that any such low-energy electron would gain sufficient thermal energy to raise its velocity above the Fermi surface. For this reason only the relatively small number of electrons with velocities near the Fermi surface can easily take on energy, and the total contribution to the thermal energy is very small. For the same reason, only electrons near the Fermi surface are important in the conduction of heat and of electricity. Thus, a study of the electronic properties of metals is simply a study of the Fermi surface and of the behavior of electrons with velocities which lie near the Fermi surface.

The description of a metal which we have arrived at is the free-electron model; only one more feature need be added to complete the picture and have a model which describes most of the properties common to all metals. This feature is the collision of electrons with

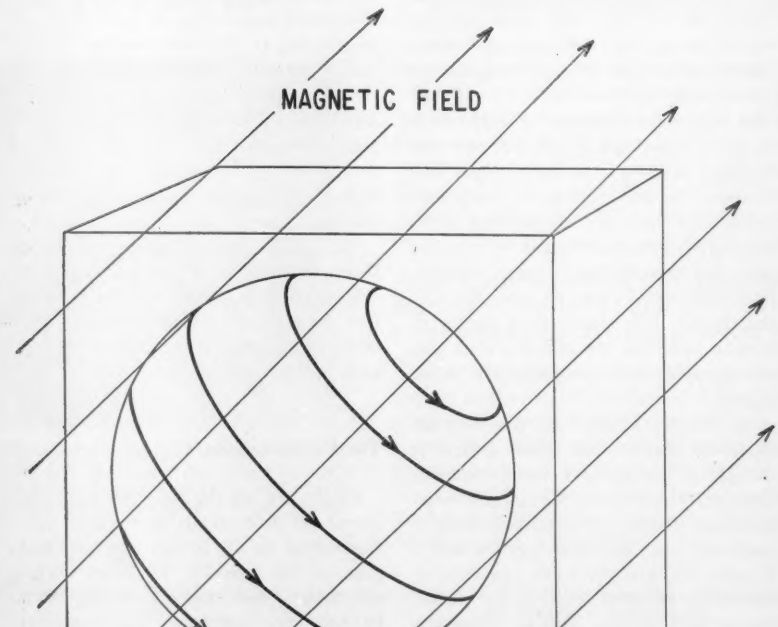


Fig. 2. The changes in velocities of electrons at the Fermi surface when a magnetic field is applied to a free-electron metal. Each electron keeps the same energy, and therefore stays on the Fermi surface, but continually changes its direction of motion perpendicular to the magnetic field.

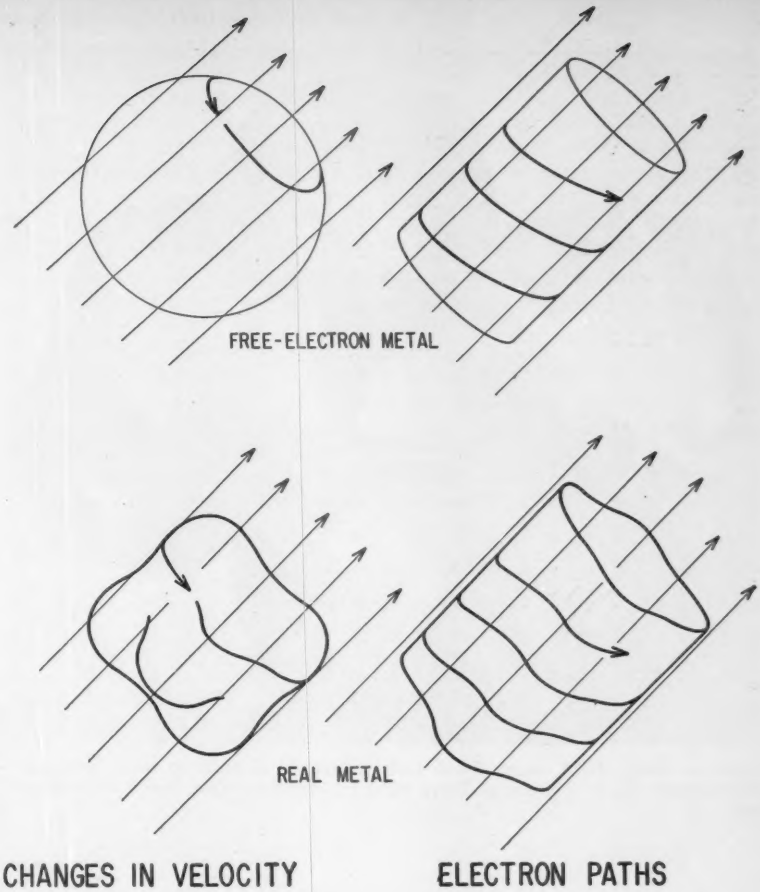


Fig. 3. The shape of the electron paths in the metal, as viewed along the magnetic field, is the same as the corresponding line on the Fermi surface which describes its changes in velocity when the magnetic field is applied. In addition, there may be a drift of the electron along the magnetic field. The distortion of the real-metal Fermi surface by the crystalline lattice is reflected in the distorted electron paths in the metal.

imperfections in the crystal. If there were no such collisions, electrons would traverse the crystal unimpeded and the metal would be a perfect conductor of heat and electricity. Actually there are always defects and impurities in the crystal, as well as vibrations of the crystal due to thermal energy. All of these "scatter" the electrons and, in doing so, are of the greatest importance to the metal's electronic properties. In the purest metals and at the lowest temperatures, the electrons may travel as far as a millimeter before colliding, but generally they travel much shorter distances.

The collection of free electrons in a metal is called an electron gas, since all the electrons speed back and forth, just as molecules do in a gas. They collide with the walls (or metal surfaces), with each other, and with various defects in the crystal. A very important difference between the electron gas and ordinary gases arises from its high concentration and the fact that only two electrons can occupy each orbit. As a consequence, the electrons of highest energy (those near the Fermi surface) move extremely rapidly, at thousands of times the speed of sound.

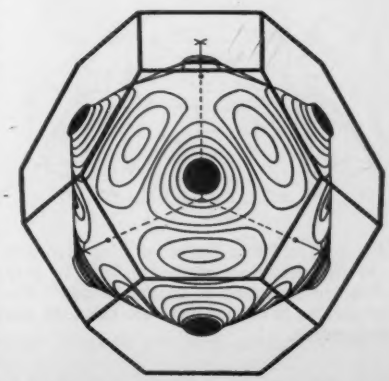
If a magnetic field is applied to a metal, these straight-line paths are bent (Fig. 2). The bending of a path by a magnetic field is a continual changing of the electron velocity and can be represented as movement of the electrons along a line in the velocity map such that the energy remains the same but the direction of motion changes continuously. Such a line would be a circle for free electrons. Thus, when a magnetic field is applied, the electrons near the Fermi surface change from velocity to velocity around the Fermi surface. As an individual electron is making this circular motion around the diagram, it is also executing a circular path within the metal. If the diagram is drawn to the proper scale (the scale depends upon the intensity of the magnetic field), the lines on the diagram will be of exactly the same shape and size as the real paths the electrons follow in the crystal (Fig. 3). This is still true even when the free-electron model is not valid, and it is an important feature of the Fermi surface: The paths followed by the high-energy electrons of a metal in a magnetic field can be drawn as lines on the Fermi surface.

There is one distinction between the true electron paths and the lines drawn on the surface. On the Fermi surface we draw circles, or at least closed lines on more complicated surfaces, but the actual electron paths may be corkscrew shaped. It is the path viewed along the axis of the corkscrew that is the same shape as the line along the Fermi surface.

Fig. 4. The Fermi surface of copper as determined experimentally by A. B. Pippard. Polyhedrons such as that drawn around the surface may be stacked together to fill all space. When a surface is sufficiently distorted to intersect the polyhedron, identical surfaces must be drawn in the adjacent polyhedrons in order to trace out complete electron paths.

Distortions

This free-electron model has been remarkably successful in explaining the properties common to metals. Even some of the differences between various metals and alloys could be attributed to differences in the numbers of free electrons and the differences in the number of defects scattering these elec-



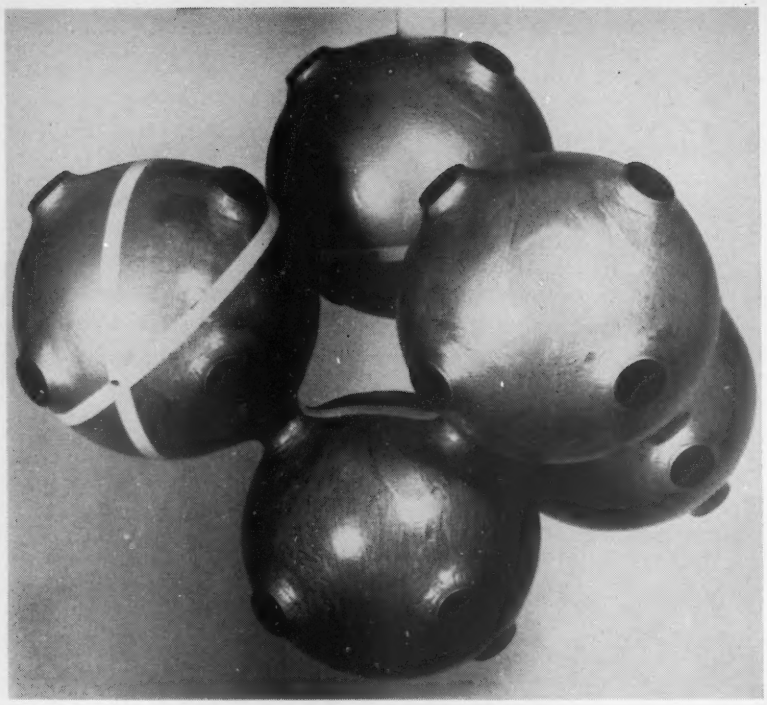


Fig. 5. A model of the copper Fermi surface, repeated in order to show "extended" electron paths (by D. Shoenberg). Three paths are shown by tapes; one is an extended path.

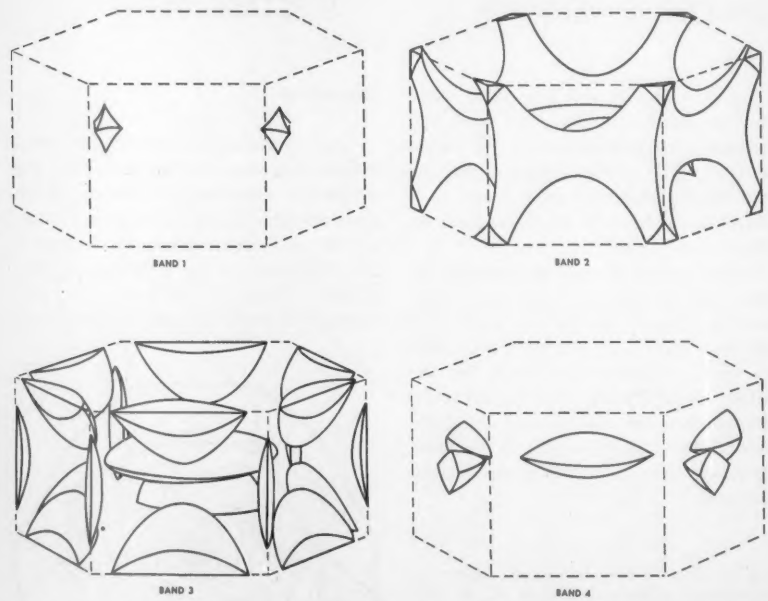


Fig. 6. The Fermi surface of zinc according to the nearly-free-electron model, showing the fragmentation of the surfaces in polyvalent metals. The various fragments are classified according to energy "bands." The surfaces result from a reassembling of a sphere. As in copper there are extended electron orbits where the surface intersects the polyhedron.

trons. Some properties, however, are completely incomprehensible in these terms. For example, the electrical resistance of most metals increases when a magnetic field is applied, but this would not be expected on the basis of the free-electron model. Peierls first suggested, in a letter to Bethe, that this increase might arise from distortions of the Fermi surface from the free-electron sphere. These suggested distortions have become more and more apparent as the experiments on metals have been refined. As the size of the distortions has been discovered, it has become difficult to understand why the free-electron model was so successful in the first place.

In the free-electron picture we forgot all about the metal crystal and thought of the electrons as completely free in their motions within the crystal. All directions looked the same to the electrons, and an electron of a certain speed had the same energy no matter in which direction it was moving. The Fermi surface was spherical. Actually the atoms of the metal are in a regular repeating array which forms the crystal. An electron which moves along a line of atoms may behave differently from one which cuts across such lines of atoms. An electron with a certain energy may have different speeds depending upon its direction of motion, and the Fermi surface would then be distorted. This in turn leads to distortions of the electron paths in a magnetic field. (In actual study of the distorted surfaces it becomes necessary to think of electron momenta rather than electron velocities, but for purposes of description these are the same.)

Such distortions differ from metal to metal and produce some of the differences between metals, although only a few properties, mostly associated with responses to a magnetic field, depend *only* on the distortions of the Fermi surface.

In the monovalent metals (for example, sodium and copper) distortions of the surface are relatively minor, and many paths taken by the electrons when a magnetic field is applied are very nearly circular. Sodium, in particular, has a nearly spherical Fermi surface. In copper (Figs. 4 and 5) the distortions are relatively large, and it becomes necessary to regard different portions of the Fermi surface as connected to each other; then, in order to draw the electron paths, it is necessary to repeat the distorted sphere over and

over in a multiply-connected surface. Silver and gold are also metals in which the electron paths may wander indefinitely perpendicular to the magnetic field, never closing on themselves.

In the polyvalent metals [for example, zinc (Fig. 6), aluminum, and lead] the surfaces are not only distorted but broken up into many pieces. There are a vast variety of electron paths (Fig. 7), many of which have little resemblance to the sphere from which they were derived. Within the past few years considerable understanding of these more complex surfaces has been achieved by calculating the fragmentation of the surfaces without regard to the accompanying distortions. This nearly-free-electron model has allowed us to unravel many of the complexities and to begin focusing on the distortions which must also be there.

Experimental Techniques

The first metallic Fermi surface to be determined experimentally was that of copper. This achievement, by A. B. Pippard in 1957, gave impetus to the increased recent activity in determination of Fermi surfaces. Most of the experimental techniques used (although not the "anomalous skin effect" used by Pippard) are based on the applica-

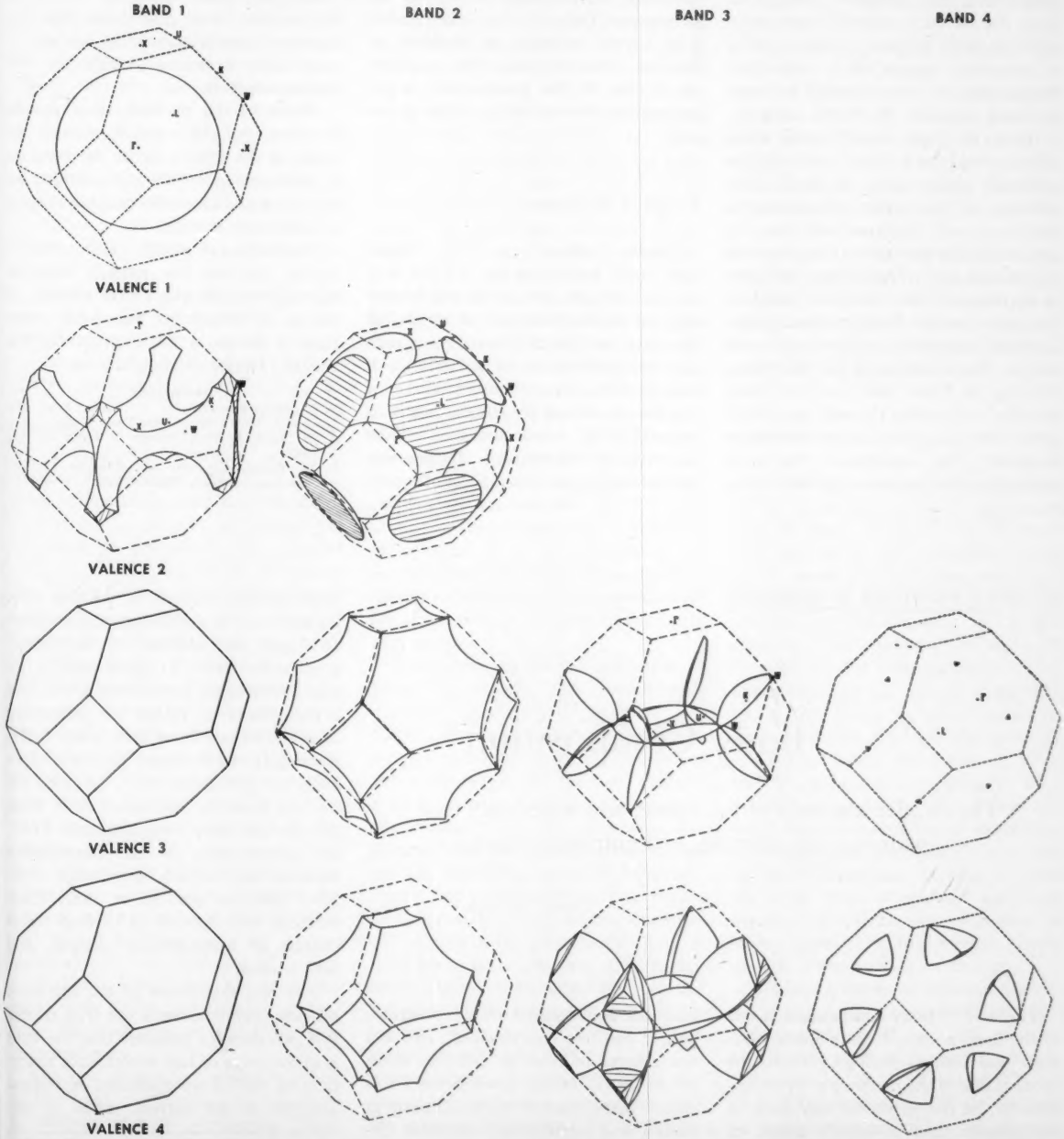


Fig. 7. The nearly-free-electron Fermi surfaces of a series of metals of the same crystalline structure but from different valence columns of the periodic table. (From top to bottom) Copper, calcium, aluminum, and lead.

tion of a magnetic field. The shapes and sizes of the paths of electrons in the metal, which reflect the size and shape of the Fermi surface, are then probed by various techniques, and parts of the surfaces can be deduced. Perhaps the most powerful technique makes use of the de Haas–van Alphen effect. This effect depends upon a restriction in the number of allowed corkscrew orbits in a magnetic field, similar to the restriction in number of allowed orbits in the atom, or in the metal with no magnetic field. This gives rise to fluctuations in many properties at high magnetic fields, notably in magnetic susceptibility, and these fluctuations are related directly to cross-sectional areas of the Fermi surface.

None of these experimental techniques could have been used without extremely pure samples of metals. The presence of impurities, as mentioned earlier, causes electron collisions. If these collisions become so frequent that an electron never completes a full path in the magnetic field without a collision, the paths become ill-defined and measurements become smeared-out and useless. Rapid advances in the understanding of Fermi surfaces have been possible only during the past few years, when extremely pure metals have been available. The requirement for long electron paths between collisions also makes it necessary to conduct these experiments at extremely low temperatures, so that the thermal vibrations, with their concomitant electron scattering, are minimized.

For the same reasons that experimental studies of the Fermi surface have only recently been possible, it is only recently that a need for this knowledge has been strongly felt. The cruder experiments could be explained by the cruder theory if the assumed concentration of electrons and their rate of scattering were chosen to fit the experiments. Only a few phenomena, such as the increase in electrical resistance with magnetic field, signaled the failure of the free-electron model and piqued the curiosity of the physicist.

Unsolved Problems

Intense activity in these highly specialized techniques has led not only to a remarkable advance in our knowledge of electron behavior in metals but also to a number of controversies such as generally arise in an active area of science. Greatly increased knowledge of the Fermi surface in metals, which is central to the whole problem of the properties of metals, has clarified our understanding of some aspects of metallic behavior but has also disrupted what we thought we understood about other aspects, just as Drude's free-electron model replaced one problem with another.

This step forward has spotlighted our ignorance of the effects of the interaction between individual electrons due to the electronic charge and the interaction due to the presence of the lattice. This latter interaction occurs as an electron moving through the crystal jostles the atoms and as they, in turn, jostle the other electrons. Such an interaction forms the basis for the theory of superconductivity, but also is manifested in metals which are not superconducting.

Whatever the problems that remain to be solved, this recent mastery of some of the intricacies of the motions of electrons in metals has provided an appealing and unusually graphic chapter in solid-state science.

Note added in proof: Various studies during the past few months have indicated that the true Fermi surface of copper is bulged out somewhat more than is shown in the direction of the square faces of the polyhedron.

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CURRENT PROBLEMS IN RESEARCH

Body Composition

The relative amounts of fat, tissue, and water vary with age, sex, exercise, and nutritional state.

Josef Brožek

The field of body composition is one of the focal points of contemporary human and animal biology. While the roots of one of the methods of investigation can be traced all the way back to Archimedes, and a baker's dozen of references date from the period 1920–1940, the overwhelming majority of the innovations in method are the contribution of the last two decades. This era was ushered in by A. R. Behnke's essay (*1*) in 1941. Many developments followed: mathematical body-composition models and calculational formulas (*2–5*); improvements in the hydrostatic technique (*6*) and measurements of body volume by helium dilution (*7*); intensive use of anthropometric methods (*8*) and the addition of roentgenographic methods (*9*); gasometric (*10*) and hydrometric approaches (*11*), and a multiplicity of means for measuring total and extracellular body water (*12*); electrolyte-determination methods, especially for potassium (*13*); methods for the simultaneous assessment of a large number of body compartments (*14*); and examination of the interrelations between the various approaches (*15–17*). With the passage of time, these methods were applied in an ever wider context of experimental, clinical, and field studies.

The fact that much of the literature on body composition is the fruit of the last two decades indicates that the field is in the stage of late adolescence rather than of full-blown maturity. A critical analysis of the current status of the

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methods confirms such an appraisal.

Cyclic fluctuations along the acceptance-rejection continuum are not unusual in the history of scientific methods. In the first, positive, creative stage the investigators, especially those who directly participate in the development of a new approach, are apt to be enthusiastic. They are impressed by how good the first approximations are. In the second, the critical, stage, the fact that these were only the first approximations is likely to be stressed. The complexities of methodology, glossed over at first, are likely to be found overwhelming. The quantitative assumptions are questioned, and the size of the standard errors rather than the typical values of the biological "constants" are stressed. It becomes clear, in time, that definitions must be sharpened, ambiguities of terminology reduced or eliminated, and quantitative assumptions replaced by factual data based on well-defined samples.

The greatest merit a theoretical model can claim is that of being stated in clear enough terms so that it can be replaced, in part or in toto, by a new set of quantitative relationships, established by further research. This was the point of view that guided Keys and me in making a systematic appraisal of body-composition methodology (*4*). Incorporated in this study were the new information on the density of human fat [obtained as petroleum ether extract (*18*)], on the density of the "reference man" (*19*), and on the mass ("obesity tissue") that is gained over a period of months by adult individuals as a result of positive caloric balance (*20*).

Ljunggren (*21*) supplemented the term *obesity tissue* with the concept of "nonobesity tissue," as a substitute for Behnke's "lean body mass." What the field needed, I feel, was not so much a new term as insistence that the existing terms be used clearly. The lack of distinction between *fat-free weight* and *lean body mass* is especially distressing. Ljunggren's "nonobesity tissue" is defined as body weight less obesity tissue, and thus it becomes close to, but not identical with, von Döbeln's (*22*) concept of lean body mass. The latter differs from Behnke's definition of the body compartment to which he gave the same name.

The first theoretical model of mammalian body composition, as visualized by Behnke and his productive "Navy school," was described in detail by Morales *et al.* (*2*). Recently Morales and Williams (*23*) again took up the problem, with emphasis on the relation between densitometric and hydrometric analysis of body composition and the logical independence of the two methods.

Clearly, there is a partial *operational* independence: in one case we measure body density (and extracellular water), in the other case we determine the total (and extracellular) body water. The bone of contention is the dependence or independence of the underlying models, specifying the compartments into which the body is partitioned, and of quantitative assumptions. Personally, I am more interested in the internal conceptual consistency of different systems of body-composition analysis and in their mutual "translatability" (*17*) than in their "independence." Thus, in principle, I look with favor on the work of Behnke and his colleagues (*15*), who replaced the previously accepted figure for the percentage of water in lean body mass (73.2 percent) by a new value (71.8 percent). In this way the estimation equation was adjusted so that the mean values for body fat as calculated from total body water (antipyrine dilution) and from specific gravity were identical (15.0 percent of body weight). Such adjustments in the biological "constants," if within the limits of empirically established fact, are not only permissible but desirable. At the same time such adjustments may be regarded as constituting a "contamination" of the two approaches and may be frowned upon by champions of independence of the densitometric and the hydrometric approaches.

The techniques for the estimation of water, fat, protein, and mineral were described and critically examined by Siri (*5*), who considered both the hydrometric and the densitometric approaches and combinations of the two. Anthropometry remained outside the scope of the presentation. Siri expressed the opinion that the anthropometric approach, including skin-fold measurements and somatotyping, can hardly be expected to give a precise quantitative picture of the gross composition of the human body, yet may yield highly useful indices where significant correlations can be demonstrated with physiological, nutritional, or clinical factors under study (*5*, p. 242).

By contrast, Tanner (*24*), in his survey of the methods of measuring body fat in man, emphasized the anthropometric procedures, including soft-tissue radiography. He pointed out that a specific contribution of the anthropometric methods is their characterization of the *distribution* of superficial body fat, whereas the physicochemical methods yield information about the total body fat.

The methods of measuring body composition, from the point of view of physical anthropology, are described briefly in the new edition of *An Introduction to Physical Anthropology* (*25*). The methodological problems were discussed in detail at a symposium on the techniques for the measurement of body composition (*26*).

A systematic, critical presentation of the results of the studies on body composition will require a similar monographic treatment and contributions from many individuals, since the range of topics is large and involves not only basic biomedical disciplines (anatomy, physical anthropology, physiology, biophysics, biochemistry) but also such diverse areas of application as internal medicine and surgery, physical education and the science of nutrition, gerontology, and actuarial science, which is concerned with somatic predictors of morbidity and mortality.

Applications

As an "interim report," this brief survey of selected areas of application may be useful. Most of the references cited deal with work published in the last 7 years. For previous work, see the review by Keys and me (*4*), with sections on the analysis of weight changes, metabolic rate, and standards of reference for such variables as cardiac output and for dosage of anesthetics. In this article, as in the earlier review, emphasis is placed on problems of human biology rather than on problems of medicine and surgery. In a measure I regret this, since I share the belief that the possibility of measuring, in pathological conditions, departures of body-composition parameters from the norm opens a new and significant avenue for quantitative evaluation of disease states (*27*). This, in turn, should provide a firmer basis for therapy.

Replacing the term *chemical anthropology* by *body composition* [to which it is closely related (see *28*)], we may take as our point of departure a recent statement by R. J. Williams (*29*, p. 267): "The importance of the analysis of body composition lies in the fact that it is capable of leading the way toward a better understanding of human differences." Basic advances in the

analysis of human biological individuality have an inherent, theoretical merit. In addition, they should facilitate the elucidation of some practical problems of "fitness," as regards both performance capacity and health. In regard to the former criterion, considerations of space travel are stimulating analysis of the human body in terms of components that vary in their vibratory characteristics (*30*). This is a novel approach to body composition and brings into focus a totally new facet of relationships between physique and the ability to perform under conditions of stress.

Disease may be regarded, also, as the result of stress. With the conquest of many infectious diseases, the significance of the "degenerative" (noncongenital, noninfectious) diseases as a factor in mortality has increased dramatically. They clearly belong to the category referred to by Williams (*29*, p. 19), who noted that "among the diseases which strike mankind there are many which need to be attacked from the standpoint of their relationship to the individuals who contract them." In regard to individuality, man's physique —with body composition one of its basic facets—calls for special attention. Interindividual differences in body composition are large; they are the resultant of interaction between genetic, behavioral (physical-activity), and environmental (nutritional) determinants; and the available data, limited as they are, document the importance of differences in physique with regard to morbidity and mortality.

Substantial advances have been made in the last two decades in the application of the techniques for studying body composition in a variety of experimental, clinical, and epidemiological contexts. In this article I consider functional and pathological correlates of differences in body composition; growth, aging, and sex; physical activity; and nutrition, with special reference to intraindividual weight loss and weight gain and to interindividual differences in fatness. Brief reference is made, also, to results in animal research.

Body Composition in Animals

While we cannot expect much help from animal studies as regards validation of the specific quantitative parameters assumed in human body-composition models, such as the average mineral content of the body, various methodological problems can be elucidated on the basis of animal data. In the past, important concepts were defined and valuable data were gathered by individuals concerned with the growth and development of farm animals. Thus, Moulton (*31*) formulated the concept of "chemical maturity" and defined it as a state in which the composition of the fat-free mass approximates constancy. He also carried out early studies on changes in body composition during underfeeding (*32*).

I cannot attempt here to survey systematically the literature on animal body composition and must limit myself to two points.

1) Potential gains will result from a closer collaboration between students of human and of animal body composition. While research with the traditional laboratory animals, from mice to dogs, cannot be neglected, farm animals, especially the pig, are of special interest for the validation of indirect methods with direct criteria derived from anatomical and chemical analysis of carcasses.

2) I refer the reader of H. Pálsson's chapter on "Conformation and body composition" (*33*), published as a part of a comprehensive review of the significant "bulges" along the advancing front of animal husbandry (see *34*). Students of human physique and of growth will find other sections of Hammond's volume rewarding reading. I was struck by the discussion of the external similarities and the profound internal differences in the hump in animals of different species and even in different varieties of the same species. Wright (*35*) points out that in zebu cattle the hump over the thoracic vertebrae originated as a store of reserve fat, and that it still shows, as do the humps of camels, marked seasonal changes in size according to the abundance of the available food supply. By contrast, in the sanga cattle, widely distributed over the tropical areas of Africa, "the comparable development of a marked thickening in the cervico-thoracic region is of purely muscular origin and bears no relationship to fat storage" (*35*).

Even though much of the work on animal body composition has been done to improve "market quality," new data of fundamental importance to animal biology are being gathered through the application of indirect methods in animal research. Specifically, quantitative analyses of body composition in vivo revealed new facts about the differences between the breeds of a given animal species (*36*)—for example, that the "hot-blooded," lighter, and faster breeds of horses not only have a much greater volume of red cells (54.0 cm^3/kg) than the Percherons (37.8 cm^3/kg) but also have a higher water content (63.8 as against 55.2 percent) and a lower fat content (12.8 as against 24.5 percent).

Rearing animals on different "planes of nutrition" not only changes their body composition but importantly affects their longevity. Experiments carried on since 1917 on a variety of animal species indicate with surprising consistency that a high plane of nutrition during early life is not compatible with a long life span (*37*). Cows fed, respectively, 88, 100, and 115 percent of the Scandinavian standard allowances prior to the first calving and the normal (100 percent) allowance after the first calving had average life spans of 86.7, 80.1, and 67.2 months. Reid (*37*, p. 63) notes that a lower plane of nutrition and the resulting retardation of early growth (and changed body composition, at least in some species) is associated with a prolongation of the life span in protozoa, water and fruit flies, silkworms, rats, and mice as well as in cattle. In view of this overwhelming evidence, the pride of mothers, pediatricians, and baby-food manufacturers in babies' plumpness and rapid growth may be somewhat unfounded. In fact, there are few problems in human biology that call for the attention of research workers more urgently than does the relation between early growth rate and adult morbidity and longevity. Unfortunately, the problem cannot be recommended as a topic for Ph.D. theses; it is much too large for investigation by a single individual. The odds are in favor of the subjects' surviving the observer.

Funtional and Pathological Correlates

Body composition is a basic feature of the machinery of the body, and it is to be expected that the existing profound individual differences in body composition will have impact on a variety of biochemical processes and physiological functions (see *4*, p. 315).

Relative obesity, even when assessed as roughly as it is in the medico-actuarial investigations (*38*), has important implications for health and longevity. Among overweight individuals of both sexes mortality is higher than it is in individuals of standard weight, and it rises, in general, with degree of overweight. The increase is the result primarily of excessive death rates from the

cardiovascular-renal diseases (diseases of the heart and circulatory system, vascular lesions of the central nervous system, and nephritis), diabetes, and diseases of the digestive system (*38*, p. 84).

It was pointed out by Tanner *et al.* (*39*) that more bodily measurements than those of height and weight must be made if maximally useful information regarding the physique-disease relationship is to be obtained. In their study, physique was characterized in terms of anthropometric measurements (including measurement of skin folds) and of derived body characteristics (surface area), somatotype ratings, and measures of bone, muscle, and fat obtained from roentgenograms (see *40*).

While in populations that are homogeneous with respect to racial origin, sex, age, and activity, the excess weight is a good indicator of fatness, for purposes of more precise analysis in heterogenous populations it is desirable to relate functional characteristics and pathology to more direct criteria of body composition, specifically to fat content.

Some aspects of body metabolism, such as oxygen consumption (for earlier references see *4*, p. 312) and amino acid catabolism, reflected in the formation and the urinary excretion of creatinine, were examined as bases for estimating "fat-free" weight and, by subtraction or from a direct prediction equation, body fat. Best, Kuhl, and Consolazio (*41*) demonstrated that healthy, lean individuals have higher creatinine coefficients (milligrams of creatinine excreted per 24 hours per kilogram of body weight) than obese individuals. The coefficient of correlation *r*, based on data obtained for 78 soldiers aged 18 to 37 years, between creatinine coefficient and percentage of body fat estimated on the basis of three skin-fold thicknesses was −0.64. At the same time, a simple index of fatness calculated as a ratio of height to abdominal girth showed a closer association ($r = 0.86$) with the percentage of body fat, and Best and his associates concluded that the creatinine coefficient, though a valid measure of obesity, is not as accurate as simpler anthropometric measures. Here the concern was with function as a potential indicator of structure, of body composition. We may take a look at the "function versus tissue masses relations" in reversed perspective.

The analysis of body composition into components of greater functional homogeneity provides more meaningful reference criteria than gross body weight or surface area (calculated from the weight and the height) for physiological functions, such as cardiac output (*42*), and metabolic processes, such as basal metabolism. It is well known that basal metabolic rate, expressed in reference to body surface ($cal/m^2/hr$), decreases in a fairly steady manner during maturity (ages 20 to 60), in men as well as in women. Shock (*43*) noted that there is no, or only a very small, decrement in basal metabolism when the oxygen uptake is related to total body water (O_2/lit.), which also diminishes with age and may be considered an index of the amount of "functioning protoplasm." Thus it appears that the metabolic rate of "cells" does not diminish substantially with age, at least not in the male. Earlier densitometric analyses of body composition (*19*, p. 790) indicated that age differences in basal oxygen consumption between normal younger and older men of the same body size was largest when the oxygen consumption per minute was related to gross body weight (age decrement of 15 percent), smaller when related to "fat-free" body weight (8 percent), and smallest (4 percent) when "active tissue mass" was used as a standard of reference.

Zak and Earle (*44*) concluded that "lean body mass" would be a better standard of reference for blood volume than body weight or surface area, particularly in obese subjects. No direct comparisons of the different standards of reference were actually made (see *45*).

Data on body composition have potential relevance for anesthesiology, especially in connection with anesthetics that may have affinity for a particular body component, such as fat. Thus, thiopental (Pentothal sodium) is highly soluble in fat, and it was believed that its anesthetic action is reduced and eventually terminated by its concentration in body fat rather than by metabolism of the drug. Price *et al.* (*46*) insist that the rate at which body fat concentrates thiopental is too slow to explain the rapidity with which the level in the central nervous system is decreased, and that, instead, the lean body tissues rapidly take up most of the anesthetic, which attains its peak concentration in the brain in less than 1 minute after intravenous injection. Thus it appears that fat plays a smaller role in limiting the duration of thiopental narcosis than has been formerly supposed. The problem calls for further investigation.

One function of the subcutaneous fat is that of an insulator. Among nude subjects, inactive during 2 hours of exposure to cold (59°F or 15°C), the core of the body is better protected in fat men. They maintain higher rectal temperatures than thin men. At the same time, their skin temperatures are lower (*47*).

Garn and Haskell (*48*) obtained statistically significant correlations between the thickness of subcutaneous fat, measured on radiographs of children taken at the lower-thoracic site, and several criteria of developmental status. Fat thickness was positively correlated with skeletal age in children 8.5 and 9.5, and 12.5 and 13.5, years of age. Children who were fatter at prepuberal age (8.5 and 9.5 years) completed the epiphyseal (tibial) union sooner, and the girls reached menarche earlier.

The fact that women do better under conditions of semistarvation is well known (*49*, p. 758). This is certain to be due to more than one factor, but body composition is likely to be involved, in view of the higher fat content of the female body. This interpretation is supported by experimental data of Baur and Filler (*50*). The survival of 8-week-old pigs deprived of calories, with water available, was longest in animals with the largest fat stores. When the animals were deprived of both calories and water, the higher water content was associated with longer survival. When the animals have access to food but are deprived of water, the time of survival is substantially reduced, and it appears to be unrelated to body composition.

In healthy young American men, serum cholesterol level is not significantly related to overweight or obesity, as determined from the radiographic measurements of the fat-plus-skin shadow at the level of the tenth rib on standard posteroanterior teleoroentgenograms (*51*). Similarly, absence of important correlation between fatness of the arm and serum cholesterol level (*r*, based on data for 88 subjects, was +0.16) was reported for adult Australian men by Whyte *et al.* (*52*), who cite the older literature.

Sex, Growth, and Aging

Profound changes take place, with time, not only in the total size (bulk) of the human organism but also in the absolute and relative contribution of individual organs and tissues. The literature on changes in body composition

with age was summarized by Mickelsen (*53*). He points out the need for longitudinal studies on adults, especially on individuals over 60, and suggests, in view of the relative obesity (higher fat content) found to be associated with greater longevity, that the role in longevity of a moderate surfeit of fat be studied in older women.

To determine sex differences in body composition, studies must be made in individuals of comparable ages. This introduces, of necessity, consideration of age trends. Garn and Haskell (*54*) have shown that the increase in subcutaneous fat, measured at the lower thoracic site on serial chest plates, is small and roughly parallel in boys (from 3.0 millimeters at the age of 6.5 years to 4.5 millimeters at the age of 10.5 years) and in girls (from 4.0 to 5.5 millimeters at the same ages). Thereafter there is a sharp sex differentiation; in the boys the thickness is stabilized at about 4.5 millimeters between the 11th and the 17th year, while in the girls there is a sharp increase, the thickness reaching 8 to 9 millimeters by the 14th year.

This difference is brought out clearly also in Pařízková's (*55*) study of 380 boys aged 10 to 17 years and of 300 girls aged 10 to 16 years, on whom skin-fold measurements were made at ten sites and totaled. Anthropometric data were supplemented by body-density determinations in studies of growth and of physical activity (*56*) and of alimentation and weight reduction (*57*).

Friis-Hansen presented original data on changes with age in body-water components, against the background of the literature (*58*) and, in a brief form, in a collaborative work (*59*). In the human fetus the total body water, expressed as a percentage of body weight, decreases from 94 percent in the first to 82 percent in the eighth lunar month. The rapid decrease in water content continues through the first year of life, from about 78 percent in the newborn child to 60 percent in children in the age group ½ year to 2 years. The extracellular component, determined by the thiosulfate method, exhibits a gradual decrease, from around 42 percent at birth to 20 percent at puberty. The intracellular water, as a fraction of total body weight, is fairly constant during the first 2 years, or at least does not show the consistent decrements exhibited by the total and the extracellular components; there is some increase in subsequent years. A greater number of determinations is needed to differentiate accidental ups and downs from genuine, systematic changes. Furthermore, it would be desirable (but admittedly difficult in vivo) to relate the water components to the "fat-free" weight rather than to total body weight.

Friis-Hansen's data were supplemented (*60*) by information on body water in adults, with particular reference to sex differences. In ten "normal" males and ten females, aged 23 to 54 years, the total body water accounted for 54 and 49 percent, respectively, of the body weight. This statistically significant difference reflects a higher relative content of total body solids in the females, and, specifically, of fat. The percentages of extracellular water, measured as the radiobromide space, are much the same in both sexes (23 percent in males and females), while, again, there is a substantial sex difference with respect to intracellular water, levels being higher in men than in women (means of 31 and 26 percent, respectively). Determinations of the total exchangeable potassium, made independently of estimates of intracellular water, showed a similar pattern and indicate that a greater fraction of body weight is accounted for by muscle tissues in the male. The conclusion that in the males there are more tissues rich in intracellular and relatively poor in extracellular material is further supported by figures on intracellular and extracellular water, expressed as percentages of the total body water: 57 as against 53 percent (intracellular) and 43 as against 47 percent (extracellular) in males and females, respectively.

The interpretation of these differences as being due to muscular development is supported by the work of Suárez and Marquesán (*61*), who demonstrated a close correlation between intracellular water [measured as the difference between the total water (antipyrine space) and the extracellular water (thiocyanate space)] and the radiographically determined cross-sectional muscle area of the leg (see also *62*).

A large number of data on the average body composition of the "normal male" (*N*, 10; mean age, 36.8 yr; mean weight, 72.5 kg; relative weight, not specified) and "normal female" (*N*, 10; mean age, 33.7 yr; mean weight, 59.3 kg) were presented by McMurrey *et al.* (*63*). The information was obtained by means of radioactive tracer methods, as well as with nonradioactive solutes (Evans blue for the determination of plasma volume). The data are given for the total body [body weight; body fat (25.8 as against 33.6 percent of body weight in males and females, respectively); fat-free solids (19.9 as against 17.8 percent); and total body water (54.3 as against 48.6 percent)] and for the intravascular, the extracellular, and the intracellular phases.

Interesting sex differences were brought out in Pitts's studies on guinea pigs (*64*). It appears that female guinea pigs have a larger compartment for fat storage than males. There are also sex differences in the distribution of fat. The female guinea pigs store about 20 percent, and males only 12 percent, of their fat in the subcutaneous fat depots. Conversely, males store more fat in the internal depots than the females.

On the basis of data obtained in the Laboratory of Physiological Hygiene, University of Minnesota (*65*), and reanalyzed in the light of new information such as data on skin thickness and density of human fat, Škerlj (*66*) emphasized that inner fat increases more rapidly with age than outer (subcutaneous) fat, relative to the fat-free body mass. The values for inner fat were obtained as the difference between total body fat estimated densitometrically and subcutaneous fat estimated on the basis of skin-fold measurements.

Age changes in body composition during maturity are likely to be complex and nonlinear. In the age range from 20 to 60 years, density decreases both in men (from 1.072 to 1.041) and in women (from 1.040 to 1.016) (*25*). This decrease reflects largely a tendency toward the accumulation of body fat, external (subcutaneous) and internal. However, other factors, such as a decrease in bone mineralization, may affect body density and complicate estimation of total body fat. Thus, the values for fat, estimated densitometrically, must be regarded as only approximations.

Parker *et al.* (*60*) compared small groups ($N = 7$) of apparently normal males and females of average ages 75 and 68 years, respectively, with younger adults. The outstanding finding is, again, the decrease in intracellular water (from 30.9 to 25.4 percent in males, from 25.9 to 22.4 percent in females), which accounts for most of the decrease in the relative value for total body water. A study reported in 1956 by Olbrich and Woodford-Williams and cited by Parker *et al.* (*60*, p. 111) showed much the

same general pattern of changes in body-water components with advanced age.

In the absence of other evidence (specifically, information on the measured amount of extracellular water and the inferred amount of intracellular water), it would be erroneous to interpret a decrease in the relative amount of total body water simply as an increase in fatness. In reality, the changes in body composition associated with aging involve the accumulation of certain body constituents (fat) and simultaneous decrement in other tissues (especially in musculature) and some demineralization of bones.

Physical Activity

Physical activity has a potentially profound influence on man's physique. It is of historical interest that Kohlrausch (*67*) in Germany became concerned with indirect methods for studying body composition in vivo in connection with studies on the effects of exercise in dogs. The high body density of overweight but lean professional football players was one of the important early findings reported by Behnke and his colleagues (*68*).

Pitts's (*64*) male guinea pigs, maintained on a severe exercise regimen from the time of weaning until they were 8 months old, differed in body composition, in the predictable direction, from the nonexercised adult series. They were slightly lighter (603 as against 708 g), the specific gravity of the eviscerated carcass was substantially higher (1.073 as against 1.057), and the total extractable fat, expressed as a percentage of "fat-free" body weight, was lower (11.7 as against 20.7 percent).

Body densities for the five athletes (chiefly weight lifters, and all under 30 years of age) studied by Behnke and Taylor (*27*) varied from 1.069 to 1.094 grams per cubic centimeter. The mean density for these five subjects is substantially higher than the mean for nonathletes of similar age. Determinations were made, also, of total body water, and of chloride and potassium spaces. The ratio of exchangeable potassium (an indicator of muscle mass) to exchangeable chloride (a measure of extracellular water) was higher in these men than in men of average physique. Another study along the same lines was reported, on the body composition, appraised densitometrically, of two groups of middle-aged men, matched in regard to height, who were characterized by long-standing differences in amount of habitual physical exercise (*69*). The principal finding was that the physically active men had a substantially larger "fat-free" weight.

Le Bideau (*70*) presented distributions of three skin folds, and of body density calculated from these skin folds, for 130 French students, 20 to 30 years of age, engaged in physical education and athletics. The values for body density were relatively high, ranging from 1.070 to 1.084 g/cm^3.

The changes in body composition in 12 soldiers as a result of 3 weeks of strenuous physical training were studied by Pascale *et al.* (*71*). There was a small average decrement in weight (−0.6 kg), there was no significant change in amount of extracellular fluid (as indicated by radiosulfate space), and there was an increase in total body water (deuterium oxide space, + 1.55 lit.). The mean increase in body density, as determined by underwater weighing, was small (+ 0.0026 g/cm^3) but statistically significant. The thickness of skin folds tended to decrease at all four sites; the decrement was largest at the abdomen. There was a small increase in basal oxygen consumption. These data are consistent with the results of the hydrometric analysis of body composition, which indicated statistically significant increases in the "cell mass," paralleled by a decrease in body fat.

Pařízková (*56*) found little difference in the average heights and weights of normally active girls and of gymnasts, aged 13 to 14 years. At the same time, the layer of subcutaneous fat was markedly thinner in the gymnasts (mean for ten sites, 9.0 mm) than in the control group (mean, about 12.3 mm). This finding illustrates the importance of body composition parameters other than height and weight.

Together with cross-sectional (group) comparisons, Pařízková carried out longitudinal studies on the effects of changes in mode of life. When the gymnasts had had 10 weeks of rest without gymnastic training, she found a weight gain and an increase in subcutaneous fat; after training had been resumed, there was no change in weight and there was a reduction in subcutaneous fat.

In the symposium on obesity (*72*), the relationship between obesity (excessive fat content of the body) and overweight (excess of gross body weight with respect to a weight standard) was examined (*73*). With reference to physical activity, comparisons were made, respectively, between Minnesota railroad clerks and switchmen, Swedish white-collar personnel and shipyard workers, Italian firemen and steel workers, and Japanese physicians and farmers and miners. When relative body weights were matched, the more active men tended to be leaner, while the more sedentary individuals were more often classified as fat, on the basis of skin-fold measurements. The results in this study brought out the need for differentiating more clearly between an excess or deficiency of gross body weight and individual differences in the amount of adipose tissue or muscularity, or both.

Lee (*74*) observed in 34 patients with chronic hemiplegia that skin-fold thickness was 22 to 45 percent greater on the diseased limbs than on the corresponding region of the normal limbs. She suggests that a unilateral increase in subcutaneous fat may reflect the decrease in activity of the diseased limb.

Physical activity is of interest to students of body composition as a factor influencing energy metabolism and placing mechanical stresses on bones and muscles (*75*) and thus affecting their growth. Here, also, we may have put the cart before the horse, and it would be well to examine the relation between human physique, including body composition, and performance (see *76*). Of special interest are quantitative data descriptive of man's structure that supplement data on gross body weight and body weight relative to skeletal size. Riendeau *et al.* (*77*) obtained significant negative correlations, ranging from −0.29 to −0.68, between the fat content of the body, estimated densitometrically, and results of seven athletic tests of motor fitness. The coefficients of correlation with body weight were also negative throughout, but they were low, and body weight did not significantly affect performance on any test except the 220-yard dash.

Appraisal of Nutriture

Body-composition analyses have an important, basic role in determining nutritional status, and nutritional research is a fruitful area of application of the "somatolytic" techniques. It is easy to see why studies in this field, typically extensive rather than intensive in character, rely heavily on the simpler anthropometric methods.

"Nutritional anthropometry" and the newer, more complex methods for describing body composition in terms of tissue masses were examined from the point of view of their significance for the science of nutrition, and their implications for physical anthropology, including the central problem of "body build" (physique), were considered (*78*). I approached the topic in a general way in an article that appeared in 1953 (*79*).

The problems were taken up in greater detail at the conference on the role of body measurements in the evaluation of human nutrition, held at Harvard University in 1955 under the sponsorship of the Committee on Nutritional Anthropometry, Food and Nutrition Board, National Research Council (*8*; see also *80*). Recommendations were made regarding the uses of nutritional anthropometry, and various aspects of the subject and closely related matters were discussed, in 11 papers. Problems of body composition were considered by Keys (*81*) at the Ames weight control colloquium.

It may be regarded as a sign of the methods' "coming of age" that we find chapters on body composition included in the best textbooks on nutrition (*82*). Keys (*83*) revised his section on undernutrition in Duncan's compendium of methods of diagnosis and treatment, in which body composition is specifically considered.

Loss and Gain of Body Weight

One of the fascinating but tricky problems of human and animal biology is that of composition of gains or losses in body weight resulting from alteration in food intake. While we must be cautious in applying animal data to man, especially as regards weight changes during adulthood, we have much to learn from studies on weight changes in animals.

Students of animal husbandry are interested in methods of analyzing body composition, especially in methods of determining water content and estimating body fat in vivo, as an indirect approach to the assessment of the energy value of rations in feeding experiments (*84*). In experiments on the "efficiency" of a diet, performed by the hundred, the weight gained by the animal is typically compared with the amount of food consumed. Animal experiments in which the original and the final body composition is examined (*85*) indicate that the assumption frequently made regarding the constant "composition" of the weight (that the mass gained consists of definite proportions of water, fat, protein, and salts) is not necessarily correct. The mass gained by rats force-fed the amount consumed by paired controls who had free access to food was almost identical, in terms of weight, with the mass gained by the controls but was somewhat lower in protein content, lower in water content, and markedly higher in fat content (23.6 as against 7.8 percent).

Of special interest is information on "fat-free" weight in pigs—a component regarded fairly generally as being of relatively constant composition. Clawson, Sheffy, and Reid (*86*) present data based on a study of 127 pigs which indicate that as the fat content of the whole empty body *increases* from 12 to 54 percent of the body weight, the water content of the fat-free portions *decreases* from 79.2 to 75.8 percent, while protein shows a slight *increase* (from 17.3 to 20.1 percent). Unfortunately it is not clear from the presentation whether the animals in the study were of similar age. One would surmise that this was the case, from the comment that "the distribution of the data for the 127 pigs studied was not adequate to study the influence of age."

Positive, though low and statistically nonsignificant, correlation ($r = 0.26$, $N = 15$ control animals) between the relative water content of fat-free carcass and the percentage of carcass fat in the ewe was reported by Kirton and Barton (*87*).

Important studies on the accumulation of body fat in the guinea pig were carried out by Pitts (*64*). Comment here is limited to the adult series. Accretion of fat is accomplished by means of two mechanisms—saturating existing adipose tissue and increasing the number or size of lipocytes. The fat content of the adipose tissue increases with increasing body fat. When the total body fat reaches about 25 percent of the live weight (less the weight of fur and gut content), the fat content of the adipose tissue reaches a saturation limit (75 to 80 percent of the wet weight). As this limit is approached, the weight of the cellular (fat-free) component of adipose tissue, as a percentage of the "fat-free" body weight, begins to increase markedly.

The data on weight gain resulting from the maintenance of positive caloric balance by adult men for a period of 6 months (*20*) were used in the development of the Minnesota system of densitometric analysis of body composition (*4*, especially p. 280). It was postulated that the tissue masses which account for interindividual differences in fatness are similar to, or identical with, the "obesity tissue." The mass gained from simple overeating contained not only fat but also "cellular tissues" and extracellular fluid. A more correct (higher) value for the density of the component labeled "cells" will alter (increase) the estimated value for fat in the weight gain. But other questions will remain: How about the extracellular component—is there a temporary increase in extracellular hydration or is such hydration present also under truly chronic conditions of obesity?

In experiments in which there was a large differential between daily caloric expenditure and food intake (about 2500 and 2000 calories, respectively) over relatively short periods (12 and 24 days), there were marked and progressive changes in the composition of the weight loss (*88*). A large part of the early weight loss was a loss in water, in spite of the fact that water was readily available to the subjects. It was estimated that the caloric equivalent of the weight loss increased from about 3000 to 8700 calories per kilogram. The estimates for the composition and the caloric equivalent of the weight were based on data for energy balance and nitrogen excretion.

In the same experiments, decrements in subcutaneous adipose tissue measured on soft-tissue teleoroentgenograms at six anatomical sites (*89*) were proportionate to the initial thicknesses. At different sites the rate of subcutaneous fat loss per kilogram of weight loss ranged from 0.1 to 0.7 millimeter.

In the department of physiology and medicine, University of Edinburgh, the problem of the composition of weight losses and weight gains was studied by Passmore and his colleagues (*90*, *91*). In three habitually thin men the weight gained over a brief period (10 to 14 days) was accounted for by the deposition of fat and protein within the existing cells, with no evidence of any retention of water. Clearly, more information is needed on the nature of materials constituting weight gain under specified conditions (such as the over-all level of energy metabolism, as affected by the amount of physical work; initial nutriture; and degree and duration of excess calorie intake).

In the weight-reduction experiments reported by Passmore *et al.* (*91*), the over-all weight losses over a period of 40 to 45 days were fairly uniform with regard to the caloric value (7000 to 8000 cal/kg) of "obesity tissue" lost. Fat constituted 73 to 83 percent of the weight lost; protein, 4 to 7 percent; and water, 10 to 23 percent.

While additional data are needed, it is now well established that the composition of tissues lost (or gained) under various circumstances will vary. This has far-reaching consequences for the applicability of indirect methods of studying body composition, especially for densitometry, which is based on the concept of intraindividual changes (losses and gains) and interindividual differences accounted for by tissues of fixed chemical composition (and density). When such a constant composition cannot be postulated as even approximately correct, information on body density still may be useful, but it must be supplemented by data on body weight, protein and energy balances, and body water, from which the composition of the weight can be calculated. This is a feasible approach to the analysis of intraindividual changes in body weight. The relation of nitrogen retention to body composition was considered by Wallace (*92*).

Novotný and Pařízková (*57*) reported weight gains of high but uniform density (0.988 to 0.989 g/cm^3) in three asthenic patients. In eight obese patients there was appreciable varation in the density of the weight loss (the ratio of weight loss to volume loss). The two values at the lower range (0.888 and 0.899 g/cm^3), below or approaching the density of fat (see *18*), are probably the result of error of measurement. We know of no body tissues that could account for weight losses of such a density. The most likely source of error is the determination of residual air present in the lungs at the time of underwater weighing.

Entenman *et al.* (*93*) compared the composition of the tissue lost, as determined from volumetric and hydrometric data, with the composition of subcutaneous abdominal adipose tissue analyzed by chemical methods on biopsy samples taken before and after weight reduction. The density of the body as a whole increases, as does the density of the adipose tissue. In the biopsy samples of the adipose tissue the fat content decreased from 79.2 to 62.3 percent in a man who lost 14.9 kilograms of body weight, and from 85.7 to 78.9 percent in a second subject, who lost 8.4 kilograms. The water content and the relative residue content of the adipose tissue rose markedly. In regard to the composition of the total weight loss, Entenman and his associates conclude that "while adipose tissues probably contribute the greatest portion of the fat (and body weight) loss during weight reduction, other soft tissues also contribute significantly to the body weight decrease by losing non-fat components."

In prolonged undernutrition the relative increase in extracellular fluid masks the true extent of the loss of soft tissues (*49*, especially p. 278). In the presence of edema, manifest or latent (expansion of extracellular space without clinically recognizable edema), gross body weight is an unreliable indicator of the extent of the departure from the prestarvation weight level. Similarly, the results of analyses performed on muscle biopsy material obtained from children suffering from protein malnutrition indicate that body weight gives too low a measure of the degree of protein loss from the muscles (*94*). In children with kwashiorkor the water content of the body is high (about 75 percent), even after visible edema has disappeared (*95*). Standard, Wills, and Waterlow (*96*) explored two methods of assessing the progress of recovery (if not the initial extent of protein depletion): (i) measurement of creatinine output, and (ii) four body measurements (limb circumferences, skin-fold thickness) which yield an estimate of the "muscle bulk" and "fat bulk." In severely malnourished children the three characteristics—increase in creatinine output, and muscle bulk and fat bulk, as related to increase in body weight—yielded ratios larger than 1 (specifically, 1.29, 1.45, and 2.35)—that is, the gain was relatively more rapid than the gain in gross weight. This is accounted for by the continued loss of excess hydration while protein and fat are being gained.

So far we have considered intraindividual weight losses and weight gains, a subject of considerable interest to students of body composition. How about comparisons between different individuals, the task for which the indirect methods of studying body composition are typically used?

Keys and I have examined (*97*), in an exploratory fashion, the density and composition of tissues accounting for interindividual differences in total body density. The analysis involved data on young men matched for height and age but differing in fatness. The average differences in weight and volume for two groups consisting of 16 fat and 21 lean men, respectively, were 29.348 kilograms and 31.279 liters, values yielding a difference in density of 0.938 g/cm^3.

Seven percent of the difference in weight was accounted for by extracellular fluid; the remainder (the total difference less the difference attributable to extracellular fluid) was attributable to fat, "cells," and bone. Since the men were matched in height, and skeletal width was not considered in their selection, we may assume (in a provisional manner, at least) that the average bone mass in the two groups was the same. This leaves for consideration fat and "cells." Calculations based on the assumptions on which the breakdown of intraindividual weight gains (*20*) was based indicated that the gross difference in mass for the lean and the fat young men was attributable as follows: extracellular fluid, 7 percent; "cells," 22 percent; and fat, 71 percent. For comparison, we considered the total weight gain in middle-aged men from overeating for 6 months; this "obesity tissue," with a density of 0.948 g/cm^3, was made up of extracellular fluid, 14 percent; "cells," 24 percent; and fat, 62 percent. The results of the interindividual (group) comparison were so close to those obtained from the analysis of mean intraindividual weight gains in the fattening experiment that it was believed the differences could arise from errors of sampling and measurement. Alternatively, only trifling differences in bone mineral would yield a proportion of "cells" to fat which would be identical with that found in the fattening experiment. It was fully realized that this study hardly scratched the surface of a knotty problem. Nevertheless, it was felt that the outcome of the study strengthened the case for this type of indirect analysis of body composition.

Johnson and Bernstein (*98*) estimated the composition of "obesity tissue" on the basis of regression analysis of the relations of body fat, cell mass, and extracellular fluid to relative body weight of 17 healthy women, 21 to 59 years old. Their body weight ranged from 60 to 250 percent of the standard. The hypothetical tissue accounting for individual differences in fatness was assigned the following average composition: extracellular water, 6 percent

(measured by inulin dilution); cell mass, 25 percent (calculated from intracellular water); and fat, 70 percent. These values were surprisingly similar to the results of densitometrical analysis reported by Keys and me (*97*). Johnson and Bernstein (*98*) measured total body water by antipyrine dilution and from it calculated the fat-free body mass. The value for fat was obtained by subtraction. The approach is an interesting one, but more definitive conclusions must be based on a larger sample, probably more homogeneous in age.

The composition of tissues accounting for the differences between groups of obese ($N = 17$) and normal ($N = 16$) females was examined by Ljunggren (*21*). Mean ages were 33 and 24 years. The average heights for the two groups were identical. The weight differential was very large (49.4 kg). Total body water accounted for 22 percent of the mass. The data on the extracellular water differed markedly, according to whether the space was measured by means of thiosulfate (result, 7 percent) or of radioactive bromide (result, 15 percent). The value for body solids (78 percent) was not broken down percentagewise, but data on intracellular water and the concentration of exchangeable sodium (15 milliequivalents per kilogram of water) were presented. Ljunggren regarded the figures as indicating that findings for the excess tissue in this study approximated those for "obesity tissue" in the study of middle-aged men (*20*). In view of the large uncertainty regarding the volume of intracellular water, stemming from the uncertainty (7 or 15 percent) in the value for the extracellular component, precise comparisons cannot be made.

The fundamental importance of such studies for appraising the validity of the densitometric analysis of body composition cannot be overemphasized.

Some Avenues of Advance

One common avenue of scientific advance is that of making increasingly precise measurements. In the field of body composition the acme of precision has not been reached, but efforts in this direction are not likely to be very rewarding. Certainly we would like to increase the reliability (repeatability) of some of the methods (especially the determinations of total body water) and the precision with which we can define and measure the extracellular water. But the principal avenue of advance involves the measurement of some additional parameters of body composition (such as the mineral content of the body) which show substantial interindividual differences and affect importantly the interpretation of the indirect criteria of body composition (such as body density).

Decreasing the uncertainty regarding the quantitative assumptions which underlie the estimation equations will be a significant contribution. In this regard, extension of the work on cadaver analysis is an especially urgent task. The anatomical and, more important, the chemical analysis of whole cadavers provides an undisputed basis for evaluating the indirect approaches, which are applicable to living man. Our information about some important facets of body composition, such as the ratio of bone mineral to the fat-free, bone-free fraction of the body is distressingly limited. As I have pointed out elsewhere (*99*), there is urgent need for additional data. Preferably, the chemical analysis should be combined with determinations of the density of the body and of its principal, anatomically and chemically separable parts. In the interest of adding to the fund of basic data for estimating the mineral content of the body and of muscle mass, selected body dimensions (circumferences, bone diameters) should be obtained as well.

Chemically, the human body is a complex system, and a great deal of time and effort can be devoted to analyzing it and its mineral and amino-acid composition. Analysis of individual organs represents, potentially, an almost endless task. To advance our knowledge of gross body composition we need to have a greater number of bodies analyzed, but the components that are of major concern are limited in number (total water, total fat, proteins, total minerals, and bone minerals). The relevant methods are well standardized. Emphasis should be placed on the clinical "normality" of bodies chosen for the analysis, and age as well as sex must be considered in the sampling process. Separation of the fat content of the nervous system from the total fat would be desirable, as the fat content of the nervous system appears to be relatively stable in the presence of large changes in the amount of depot fat.

The tendency to devote a great deal of effort to a small number of specimens is understandable, and the contributions of Mitchell *et al.* (*100*), Widdowson, McCance, and Spray (*101*), and Forbes *et al.* (*102*) have significantly enriched the meager treasury of indisputable facts about the composition of the human body. Nevertheless, there is room for more numerous but less detailed analyses, limited to determinations of water (by desiccation), fat (by ether extract), and ash. Successive analyses of the same human body by indirect and direct methods is still an unfilled desideratum.

Some ideas regarding methods occur again and again, at different times and in different places. In this category belong the attempts, repeated and uniformly disappointing when applied to living man, to determine body volume (a value needed in calculating body density) from changes in the air pressure of a chamber (see *49*, p. 183, for references going back to 1916). I know of at least four laboratories in this country in which substantial effort has been invested in this approach during the past 10 years. Yet, unfortunately, the "negative results" have not been reported, and thus each investigator is forced to start from scratch instead of being able to proceed from the point where his predecessors left off, or able at least to avoid the same blind alleys. As far as I am aware, only one abstract —and that a preliminary and too optimistic one—concerning a method for determining body volume of living man on the basis of air displacement has appeared in print (*103*).

Since a number of scientific disciplines interact in defining several of the parameters of body composition, a salutary influence is exerted by the efforts to develop a larger system, one in which the individual subsystems (such as the densitometric and hydrometric analysis of body composition) are considered in terms of their conceptual consistency and operationally defined "translatability." This matter has been considered in the past, but additional information on the interrelations between the body compartments defined and determined by different approaches is needed. This purpose is best served by the simultaneous application of the different methods on carefully defined samples of subjects.

Greater internal consistency of the body-composition models is desirable from a strictly theoretical standpoint. At the practical level, information is needed for "translating" the data obtained by manipulatively simpler techniques into the more complex and com-

prehensive systems, and for interpreting the physiological significance of the relationships between body components and functional (physiological), normal metabolic (see *104*), and pathological processes.

The practical needs are served by relating skin-fold thicknesses (*105*), or roentgenographic measurements of the skin plus the subcutaneous adipose layer (*106*), to body density. More important, however, is the potential gain to be derived from the rigorous comparison of approaches that involve the use of the same concepts (constructs) but arrive at them through different operational procedures.

Thus, from the practical as well as from the theoretical point of view, a simultaneous application, to a carefully defined sample or samples of individuals, of the major techniques for studying body composition may be regarded as the major avenue of advance in this field.

Science is an ongoing process. There are ideas and techniques (*107*) that open totally new vistas as regards the analysis of body composition, there are gaps to be filled, and there are syntheses to be attempted even if these are destined to be ultimately replaced by a more valid, more precise set of quantitative assumptions.

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Science and the News

The Space Administration: It Was Once Criticized for Slowness But Is Now Criticized for Speed

If the nation's space technology moves along with anything like the speed being shown by the National Aeronautics and Space Administration in its administrative decision-making, there may be ample justification to support the intrepid optimism of those who believe the U.S. will land men on the moon before the Soviets.

In a recent 30-day period, from 24 August to 23 September, NASA has selected Cape Canaveral for expansion into a site from which the U.S. will launch its manned space flights to the moon and beyond; picked a government-owned ordnance plant in New Orleans for the fabrication of launching vehicles; named Houston, Texas, as the location for a new $60-million space-flight command center for manned missions; hired new subleaders; and revamped its organizational structure.

Some measure of the rapidity with which NASA has been lining up its ducks for the moon shot is apparent in the fact that both NASA public information specialists and newsmen alike have been caught unawares by the sudden stacatto of "immediate releases" from NASA officialdom, each release spelling out a key and expensive decision for the future of the country's multibillion-dollar space effort. Information on NASA's reorganization, for example, was released on Saturday afternoon, pulling science reporters away from their day off—an unholy act in press agentry.

All this suggests that a new sense of urgency pervades the space agency. If there is a single factor reponsible for this sense of urgency it seems to be James E. Webb, NASA's administrator. Webb is a nonscientist and makes no pretense about the fact. But he is what President Kennedy wanted for the job—a man of keen political acumen, commendable experience in government and industry, and a man who understands policy-making and organization. Webb is also gaining a reputation as the Capital's most mellifluent speaker.

Webb has already appeared before one or another congressional committee more than 30 times, and just when he thought the debating and question-answering were behind him for a while, as he recently told a National Press Club luncheon, the Senate Aeronautical and Space Sciences Committee had scheduled a new set of hearings on NASA's program for 26 September.

Paradoxically, NASA, which has often been criticized for moving too slowly, is now being criticized for moving too fast. The Senate hearings, Webb said, were being held to reexplore the 10-year space effort asked for by President Kennedy because of a feeling in and out of Congress that the multibillion-dollar program had been accepted too quickly. (The hearings were postponed by the Senate Committee at the last minute because of scheduling difficulties.)

Certainly, the public debate that was anticipated following the President's challenge to the nation on 25 May that Americans should go to the moon never materialized. Similarly, congressional debate was limited to some expressions of skepticism, but little more, and the Administration got almost all of its $1,784,300,000 request. What debate there was came largely from some scientists who questioned whether the moon trip was necessary and asked whether the vast sums needed to finance a manned expedition to the moon might be better spent for a host of terrestrial challenges. But even these critics have become less critical of late.

Surprisingly, perhaps, the fact that President Kennedy's 10-year, $35-billion proposal has met with an eloquent silence and an eloquent acceptance is causing concern among many of the Administration's political observers. These observers know that this year's request for appropriations will be the smallest request for the next decade and that the requests for ever-increasing NASA funds will be decided on an annual basis. If the public or Congress waivers in its support of the effort, a set-back could prove disastrous.

If, for example, the thrill of U.S. space events or the pressure of Soviet successes wears thin, it might take a more mature public attitude to sustain the effort. It is for this reason that NASA must, concomitant with its rush to the launching pads, attempt to create better understanding of what it is trying to do, and why.

Space officials are not unaware of this potential dilemma. Webb, for example, always takes pains to underscore aspects of the 10-year space

program other than those related to manned lunar expeditions. And NASA's recent reorganization, in addition to streamlining the chain of command and tightening up an organization that grew topsy in a hurry, reflects the shotgun attitude. The changes place emphasis on four major areas of NASA's 10-year program: manned space flight, including lunar exploration; space sciences, in terms of unmanned scientific investigation of space, the moon, and the planets; practical applications of space technology, including operational weather and communication satellites; and advanced research and technology in both aeronautics and space.

Moon Czar

Webb's insistence that NASA's program must be accepted as more than just a race to the moon is also one of the chief reasons he has steadfastly fought considerable pressures that a "czar" be appointed to head the manned lunar effort. It would not be an understatement to suggest that Webb's biggest headache today is trying to provide NASA immunity against "czaritis."

Even before President Kennedy threw down the moon gauntlet on 25 May scientists and industrialists, both in and out of government, were grousing for a moon manager the likes of Leslie Groves or William F. Raborn or Hyman Rickover. It is little wonder that the press promptly dubbed D. Brainerd Holmes, a Radio Corporation of America executive picked by NASA to head its newly created Office of Manned Space Flight Programs, the "moon boss." It is now apparent, however, that there will be no moon boss for the present, at least. Holmes will report directly to Robert C. Seamans, Jr., NASA's associate administrator. So, too, will the heads of the three other newly created NASA offices established in the recent reorganization (to be effective 1 November). Rather than by a czar, the lunar program, as well as all other NASA activities will still be controlled by a "troika-like" board comprised of Seamans, Webb, and NASA's deputy administrator and scientific spokesman, Hugh L. Dryden.

Nonetheless, pressure will still be brought to bear on Webb, on the little publicized but powerful National Aeronautics and Space Council (headed by Vice-President Lyndon B. Johnson) and on President Kennedy to appoint a czar to oversee the manned lunar effort if for no better reason than to personify the sprawling, complex inanimateness that characterizes a modern technological endeavor.

In the coming months the nation will again, or still, depending upon one's view, be treated to a plethora of space news. During the first two weeks in October, earthbound space experts will describe every detail of space research to the 12th International Astronautical Congress meeting in Washington (1–7 Oct.) and to the American Rocket Society's "Spaceflight report to the nation" (9–15 Oct.) in New York. Hopefully, these meetings will be capped by the test firing of the Saturn booster, the earth-orbit of a chimpanzee, and with effort and luck, the earth-orbit of the first U.S. astronaut before the year's end.

Continuing debate will also center on everything NASA does or does not do. The military can be counted upon to carp that space doings are really its responsibility, as the Soviets demonstrate. And almost every aspect of the civilian space program will invite stereophonic controversy in and out of government: solid boosters versus liquid boosters; big boosters versus rendezvous techniques; instruments versus men.

One cannot quarrel with these intramural squabbles among experts. After all, NASA is spending, or will spend, almost 1 percent of the gross national product over the next several years, and its every success or failure has military, political, psychological, and social import for all men.

But one can question whether the public might not become confused or sated, if it is not already. One wonders, for instance, how many Americans can or even want to distinguish between Ranger and Rover, a Saturn and a Surveyor, a C-1 and an S-1.

There is the danger that the entire space program has been sold on the attractive supposition that the U.S. will beat the U.S.S.R. to the moon. Conceivably, the U.S. could lose this race. What now seems to be called for, and NASA is beginning to realize this, as is reflected in its reorganization, is the need to create a better public understanding of the nation's space needs and aims.—HOWARD SIMONS.

While Howard Margolis is on vacation, his section will be written by guest reporters. Howard Simons, this week's guest, is on the staff of the Washington Post.

Fish Flour: Action by FDA Starts Row over This Promising Answer to World's Need for Protein Foods

Fish flour, an inexpensive, tasteless food supplement with great potential for ending protein deficiencies in newly developing nations, is en route to becoming the subject of a confusing public controversy in Washington.

At issue is a preliminary action by the Food and Drug Administration which has the effect of withholding approval for sale in this country of flour made from whole fish. The final decision hinges on a lengthy review process, possibly including public hearings. FDA estimates the review may take "a minimum of 8 to 10 months." Its decision may well be followed by a court appeal.

Though the wholesomeness of the product is not questioned, FDA said it may have to be regarded as "adulterated" because the flour is "made without the removal of those portions of the fish, including the intestines and the intestinal contents, that are not normally regarded as acceptable for human food in the United States."

Ironically, the developers of fish flour feel there is little potential market for the product in this protein-rich country. Their attention is fixed on the flour's possible uses in Africa, Asia, and Latin America, where marked protein deficiencies afflict massive numbers. FDA approval is not required for shipment abroad, but health authorities in many nations look to FDA for guidance and insist on its stamp of approval before they will allow importation of an American food or drug product.

With foreign concern about FDA approval in mind, the BioVin Corporation, of Monticello, Ill., a domestic producer of fish flour, petitioned FDA for "standard of identity" for its product.

BioVin's petition to the FDA had the tacit support of some Administration officials, who were concerned that Soviet propaganda might find a choice issue in the United States' sending abroad a foodstuff that it would not permit its own people to eat.

Extremely distressed by the FDA treatment of the petition, those interested in the development of fish flour have been enlisting congressional and Administration support to bring pressure on FDA. FDA, in turn, has complained about threats to its integrity. As one newspaper account put it, FDA officials "fear that approval of the flour would undermine their agency's program of keeping foul matter out of food." It

went on to point out that the flour "is made by grinding whole fish, including scales, eyeballs, and intestines," and warned that "the controversy over fish flour could develop into one of the agency's major battles."

Into the burgeoning fray has come George McGovern, director of Food for Peace. He spoke last week in Washington before the International Conference on Fish in Nutrition, sponsored by the Food and Agricultural Organization of the United Nations. When properly purged of impurities by heat and washing, he declared, fish flour "is no more adulterated than pigs' feet, or liver or brains or tripe or tongue, which has been properly prepared."

Also joining the battle was Senator Douglas, who announced he would serve fish-flour preparations to his congressional colleagues to publicize its wholesomeness. While Douglas and a number of Senators relied on simply vocalizing their displeasure over FDA's action, several House members introduced bills to exempt fish flour from FDA's jurisdiction. A White House source said that the President himself was displeased by the FDA position and that FDA would not be permitted to stand in the way of a promising solution to mass dietary deficiency in nations we seek to help. The White House was of the opinion that perhaps too much significance had been attached to the FDA action, and that foreign acceptance could be achieved without FDA approval.

For its part, FDA, which is an independent agency, said it would not be pressured by the Congress or the White House into disregarding its obligations to the American people. It said that, as part of the review process, it had requested public comments and had received the wholehearted approval of a number of organizations, including the General Federation of Women's Clubs. And it said it discerned additional support coming its way, some of it from Capitol Hill.

Source of Protein

Very likely to be obscured in the developing row is the great potential inherent in this unpalatable-sounding substance. Also known as fish protein concentrate, fish flour has been produced off and on in various parts of the world since the late 19th century. In recent years it has taken on special significance because of findings of serious protein deficiencies in many national diets.

Its advantages are said to be numerous: It is cheap and highly concentrated. It is nonperishable, even in hot, humid climates. Because it can be made virtually tasteless, it is compatible with a variety of dietary preferences. In small, but still potent quantities, it is undetectable as a supplement in bread and grain preparations, which are the dietary mainstays in the nations most afflicted by protein deficiencies.

Fish flour's potential as a protein supplement has nowhere been realized on a large scale, though it is produced and used in Sweden and a number of other countries.

Many of the most hopeful workers in the field emphasize that technical and production problems must first be overcome, and that these may prove minor as compared to the difficulties of distribution, marketing, and consumer education.

These uncertainties, however, are not shared by the man whose fish-flour petition brought on the FDA action, Ezra Levin, an aggressive businessman and scientist who is president of the BioVin Corporation. BioVin, employing a process of azeotropic dehydration and extraction of lipids from whole, granulated fish, offers a 70-percent protein concentrate at 15 cents a pound, F.O.B. its Monticello, Ill., plant. BioVin's process is well regarded by workers in the field, and its petition was filed with the "cooperation and approval" of the Bureau of Commercial Fisheries, which has a $50,000 fish-flour research project under way at College Park, Md.

To add further to the potential for public confusion on the issue, the petition was filed by a Senate staff aide, with the endorsement of several members of Congress, principally from New England fishing states. This unnecessary but by no means unique procedure has been cited by FDA officials as a sign of threats to the agency's integrity and has precipitated fight-to-the-death pronouncements.

FDA officials proudly point out they have been fighting "filth in food" for 50 years, and say they are not going to establish a precedent that will open the way to a lowering of standards. The fish-flour developers, on the other hand, point to FDA's allowable tolerances for rat dung in wheat.

The Administration, of course, has had more important things on its mind, but considering the interest that it has shown in fish flour's potential, it is difficult to avoid the reflection that this row could have been avoided—D.S.G.

Announcements

A formal statement on **civil defense and modern war**, issued this month by the Society for Social Responsibility in Science, calls for "full disclosure . . . of the facts about civil defense, and nuclear and biological war," since ". . . many inevitable effects . . . are largely ignored in public discussion: the fundamental disruption of the structure of society; genetic mutations in all living things, and unpredictable changes in the ecological balance of the world . . . ." To avoid these, the society calls for an "unwavering search for alternatives . . . ": "Mediation, a stronger United Nations, international law, and other non-violent approaches to conflict situations must be pursued and the world's resources put to constructive use."

The SSRS is defined as "an international group which holds that scientists are morally responsible for the consequences of their work to society, and that scientists should devote themselves to constructive rather than destructive work." (E. J. Lieberman, 24 Claflin Rd., Brookline 46, Mass.)

According to the U.S. Office of Education, of the 13,400 **students working for doctorates** in the academic year 1960–61, more chose the physical sciences than any other branch of science. About 2400 of the candidates chose fields such as chemistry, metallurgy, physics, geophysics, and oceanography. Next in popularity were the fields of education, with approximately 1900 doctoral candidates; social sciences, with 1600; engineering, with 1500; and the biological sciences, with nearly 1400.

Of the approximately 314,000 students enrolled in 1959–60 as candidates for graduate degrees, 9800 received doctorates in that academic year. About two-thirds of those enrolled had completed less than 1 full year of graduate work and another third had completed more than a year.

An exhibition of **Soviet medical services and equipment**, organized by the U.S.S.R. Ministry of Health, has begun a 63-day tour of the United States. The exhibition, now appearing in Oklahoma City, is scheduled to spend a month at the Chicago Museum of Science and Industry, and will conclude its tour at the University of Minnesota. Designed "to acquaint

Americans with the organization of medical care in the USSR, [and with] the development of Soviet medical science, surgical equipment, and drugs," the exhibition will include sections on cardiovascular ailments, cancer, thoracic surgery, and space medicine.

The **Jaques Cattell Press** in Tempe, Arizona, publishers of *American Men of Science, Directory of American Scholars*, and *Leaders in Education*, has recently become a wholly owned subsidiary of the R. R. Bowker Company, New York. Daniel Melcher has been appointed president of the press, succeeding Garrison Cattell, nephew of the late Jaques Cattell. Mrs. Jaques Cattell will continue as vice president. The press will remain in Tempe.

A series of **geology reference pamphlets** for elementary and secondary school science teachers has been initiated by the American Geological Institute. The series will cover information sources, classroom teaching aids, and laboratory and field projects. Three pamphlets presently available in the series are (i) *Sources of Geological Information*, (ii) *Selected References for Earth Science Courses*, and (iii) *Films for Earth Science Courses*. (Publications, AGI, 2101 Constitution Ave., NW, Washington 25, D.C. Price: $0.10 each)

Annual stipends for Public Health Service **postdoctoral fellowships**, administered by the National Institutes of Health, have been increased by $500, to $5000 for the first year, $5500 for the second, and $6000 for the third. The increase applies to postdoctoral research fellowships (new or continuing) awarded on or after 1 July 1961. Allowances for dependents, travel expenses, and research supplies have not been increased.

A **science information service**, designed to aid industry and scientific institutions in implementing research and development projects, has been inaugurated by the Franklin Institute's Technical Library. The service offers literature searches in any area of mathematics, engineering, physics, chemistry, and industrial processing, and provides bibliographic compilations (author-title-source), annotated bibliographies, abstracts of articles, current literature monitoring, and translations. (Alec Peters, SIS, Franklin Institute, Philadelphia 3, Pa.)

Pupae of **saturniid silkmoths** are being solicited in connection with a research project being conducted at Northwestern University. Because a bacterial infection destroyed the university's silkworm crop, *Hyalophora cecropea* pupae in particular, as well as other species, are urgently needed. The university is willing to pay "good prices" for the specimens. (Lawrence Gilbert, Department of Biological Sciences, Northwestern University, Evanston, Ill.)

A new service is available through which an **exchange of homes** is arranged between American faculty members who wish to visit Europe and Europeans in various professional categories who wish to visit the United States. A registry of homes and apartments available for exchange both in North America and in Europe is maintained. Fees range from $25 to $75. (Quid Pro Quo, 865 West End Ave., New York 25)

A recent Soviet article on **antineoplastic therapy** reports that "existing antineoplastic preparations exert a therapeutic effect only on certain definite tumors and fail to influence others," and concludes that "the idea of developing a universal medication against all malignant tumors is absurd." The article is one in a collection of translations compiled from recent issues of the U.S.S.R.'s *Pathological Physiology and Experimental Therapy*. Other articles in the collection deal with experimental cancer of the stomach; hemoglobin changes in malignant and benign tumors; burn trauma and radiation sickness; and an improved heart-lung apparatus. (Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. $1.50)

The services of the Oak Ridge Institute of Nuclear Studies' **traveling lecture program**, sponsored by the U.S. Atomic Energy Commission, are offered free of cost to colleges and universities in the southern area. A list of the 132 scientist-lecturers and their topics is available on request. (Traveling Lecture Program, P.O. Box 117, Oak Ridge, Tenn.)

A bibliography of **mathematical research articles published in Communist China** from 1949 to 1960 will be issued by the American Mathematical Society, with the support of the National Science Foundation. (AMS, 190 Hope St., Providence, R.I. $1)

Grants, Fellowships, and Awards

Applications for the 1962 Glorney-Raisbeck fellowship in the **medical sciences** are being accepted by the New York Academy of Medicine. The $6000 fellowship is open to all physicians, with preference to candidates from the New York City area. Fellows will be expected to spend the year in full-time investigation, or in study in a special area of science for a career in research and teaching. Deadline: *1 December*. (Executive Secretary for Medical Education, New York Academy of Medicine, 2 E. 103 St., New York 29)

Nominations for career investigators in **leukemia research** are being solicited by the Leukemia Society. A 5-year award of $10,000 to $15,000 per annum, renewable to 10 years, will be presented to qualified investigators in basic science whose research is broadly related to the problem of leukemia. Nominees must serve as a regular member of the faculty or staff of their institution. Deadline: *1 November*. (Herbert C. Lichtman, 405 Lexington Ave., New York 17)

Two research fellowships in **marine biology**, financed by the U.S. Office of Naval Research, are available through the Scottish Marine Biological Association. Applicants should have a master's degree, or its equivalent, in biological sciences. Fellows will be trained in analysis of plankton collections obtained from the Continuous Plankton Recorder survey of the northeastern Atlantic Ocean and the North Sea. The survey is to be expanded to include new routes across the Atlantic and in North American waters. Funds will be available for attendance at scientific meetings in the United Kingdom and Europe. Salaries will range from £800 to £1000 per annum. Applications should be made immediately. (Officer-in-Charge, Oceanographic Laboratory, Craighall Rd., Edinburgh 6, Scotland)

The following awards for support of **medical research and teaching careers** are available through a program recently established by the U.S. Public Health Service and administered by the National Institutes of Health.

Research career awards, intended for experienced investigators, will provide full-career support in 5-year increments. A yearly maximum of four

applications may be submitted by each institution.

Research development awards, intended for younger postdoctoral investigators with 3 years' professional experience, will be made initially for 5 years and are renewable for up to 5 additional years. No limit is placed on the yearly number of applications to be submitted by individual institutions.

Recipients of awards in either category will be responsible to their sponsoring institutions. (Career Development Review Branch, Division of Research Grants, NIH, Bethesda, Md.)

Meeting Notes

The 12th national conference on **standards** will be held from 10 to 12 October in Houston, Texas. The conference will include sessions on the philosophy and practice of standardization; plastics, safety, and data processing standards; optimum distribution through standardization; and a case history of growth through standards. (American Standards Association, 10 E. 40 St., New York 16)

The 1961 international conference on **luminescence** will be held from 9 to 13 October at New York University. The conference, jointly sponsored by the university, the Air Force Aeronautical Research Laboratory, the Army Research Office (Durham, N.C.), and the Office of Naval Research, is similar to one held in Paris in 1956. (Grace M. Spruch, Physics Department, New York University, Washington Square, New York 3)

A symposium on **optical character recognition** will be held from 15 to 17 January 1962, in Washington, D.C. The meeting will cover available equipment, current research, requirements of potential users, and future progress. Demonstrations of optical character recognition systems in operation in the Washington area will be arranged. (Josephine Leno, Code 430A, Office of Naval Research, Washington, D.C.)

A **chemistry symposium**, honoring Carl S. Marvel, will be held on 27 and 28 December at the University of Arizona. (H. Freiser, Department of Chemistry, University of Arizona, Tucson)

New Journals

Environmental Health Letters (introductory issue), Aug. 1961. G. Fishbein, publisher. Environmental Health Newsletter, National Press Building, Washington 4, D.C. Semi-monthly. $50 per year.

Food Research Institute Studies, vol. 1, No. 1, Feb. 1960. M. K. Bennett, director. Food Research Institute Studies, Stanford University, Stanford, Calif. Tri-annually. $2.50 per issue; $7 per year.

Sportärztliche Praxis, Heft 2-3, 1961. Verlag Brüder Hollinek, Wein III, Steingasse 25, Austria. Quarterly. DM. 3 per issue.

Infrared Physics, vol. 1, No. 1, Mar. 1961. W. K. Weihe, S. Passman, N. Migeotte, T. S. Moss, Eds. Pergamon Press, Inc., 122 E. 55th St., New York 22, N.Y. Institutions, $20 per year; individuals, $10 per year.

Vision Research, vol. 1, Nos. 1 and 2, June 1961. T. Shipley, Ed. Pergamon Press, Inc., 122 E. 55th St., New York 22, N.Y. Institutions, $30 per year; individuals, $10 per year.

Experimental Agriculture and Animal Husbandry, vol. 1, No. 1, May 1961. R. N. Sandiford, Ed. Australian Institute of Agricultural Science, 226 Clarendon St., East Melbourne, C.2, Victoria. Quarterly. £5 (Australian) per year.

Scientists in the News

Barry Commoner, professor of plant physiology at Washington University and a member of the St. Louis (Mo.) Committee on Nuclear Information, will be a visiting lecturer in Moscow and Leningrad this month, in response to an invitation from the U.S.S.R. Academy of Sciences.

Recent staff appointments at the Wyeth Laboratories' Steroids and Natural Products Section:

Herchel Smith, of Manchester University, has been named manager of the section.

David Herbst, of Syntex, S.A., and **James F. Fisher**, of Colgate Palmolive Company, will become senior research chemists.

Daniel M. Teller, of duPont Laboratories, **George H. Douglas**, of Manchester University, and **Theodore J. Foell**, of Lederle Laboratories, will become research chemists.

Roger Revelle, on leave from his post as director of the University of California's Scripps Institution of Oceanography, has been appointed science adviser to the Secretary of the Interior.

Reinhold Rüdenberg, emeritus Gordon McKay professor of electrical engineering at Harvard, will receive an Elliott Cresson medal of the Franklin Institute "for his many contributions to the electric power industry."

Kenneth F. Girard, technical director of clinical laboratories at the Boston dispensary and assistant professor of bacteriology at Tufts Medical School, has been named assistant director of the diagnostic laboratories of the Massachusetts State Department of Health.

Carey Croneis, professor of geology, and **W. V. Houston**, physicist and past president of Rice University, have been named chancellor and honorary chancellor, respectively, of the University.

The following senior faculty members in the University of Maryland's department of physics will be on sabbatical leave during 1961–62:

John S. Toll, chairman of the department, will be at the Institute for Theoretical Physics, Lund, Sweden. **Howard J. Laster**, associate chairman of the department, will be acting chairman during Toll's absence.

George Snow will be at the European Organization for Nuclear Research (CERN), Geneva, Switzerland.

S. Fred Singer will be at California Institute of Technology's Jet Propulsion Laboratory.

Leon Gintzig, director of hospital administration research and development for the Veterans Administration, has been appointed associate professor of hospital administration at George Washington University College of Government, Business, and International Affairs.

Frederick S. Brackett, biophysicist, has retired from the U.S. Public Health Service's National Institute of Arthritis and Metabolic Diseases. Brackett, chief of the section of photobiology in the institute's laboratory of physical biology, will be retained by the institute as a consultant.

Recent staff appointments in the U.S. Atomic Energy Commission's Division of Reactor Development:

Robert W. Ritzmann, nuclear engineer in the division's evaluation and planning branch, has been named AEC Scientific Representative to Canada.

Ira F. Zartman, chief of the division's reactor physics branch, has been named AEC Scientific Representative in Tokyo.

Nelson Sievering, senior AEC representative in the U.S.-Euratom cooperative program on the peaceful uses of atomic energy, Brussels, Belgium, has returned to the U.S. as the division's associate director for advanced systems. He is succeeded by **John A. Erlewine**, special assistant in the research and industrial development section.

Torkel Weis-Fogh, of the University of Copenhagen, has been appointed Harvard University Prather lecturer in biology for the current academic year.

V. Harry Adrounie has been appointed Air Force adviser to headquarters of the 3rd Aeromedical Evacuation Group, and detachment commander of the 1st Aero-medical Transportation Group at Mather Air Force Base, California. He was previously environmental medicine officer in the Surgeon General's Aerospace Medicine Division.

Harry C. Allen, Jr., of the National Bureau of Standards, has been named chief of the bureau's Analytical and Inorganic Chemistry Division.

Recent faculty appointments at St. Louis University's Institute of Technology:

Charles B. Belt, Jr., of the University of Utah, will become assistant professor of geology and geological engineering.

Leonard C. Jones, of Emerson Electric Manufacturing Co., will become associate professor of engineering.

Joseph V. McKenna, of Syracuse University, will become professor of engineering.

Stanislaw A. Vincenz, of the Industrial Development Corp., Jamaica, B.W.I., will become associate professor of geophysics and geophysical engineering.

F. Norman Briggs, associate professor of physiology at Tufts University School of Medicine, has been appointed professor in the University of Pittsburgh School of Medicine's newly created department of physiology. **William D. Peckham**, head of the biochemistry department of Schering Corp., has been appointed research associate in the new department.

Leo Esaki, a physicist for International Business Machines Corporation, will receive a Stuart Ballantine medal from the Franklin Institute for his discovery of the tunnel diode.

Recent staff appointments in the U.S. Office of Naval Research:

F. Joachim Weyl, former ONR research director, has been named deputy chief and chief scientist. He succeeds **Thomas J. Killian**, who resigned to accept a position in private industry. **Shirleigh Silverman**, head of the Naval Research Group, will replace Weyl as research director.

Joseph F. Saunders, who has been with the ONR since 1952, has been named head of the medicine and dentistry branch in the Biological Sciences Division. He succeeds Capt. **James A. English**, who has retired.

Arthur R. Von Hippel, director of Massachusetts Institute of Technology's Laboratory for Insulation Research, has been elected vice president in charge of fundamental materials research for U.S. Sonics Corporation, a firm which designs and manufactures solid-state materials and devices.

William E. Swinton, principal scientific officer of the British Museum (Natural History) and one of the three general secretaries of the British Association for the Advancement of Science, has been appointed head of the Royal Ontario Museum's life sciences division, Toronto.

Recent Deaths

Sister **Aloysius Marie**, 82; organizer of the physics department at Trinity College; physics teacher at the college from 1915 until her retirement in 1951; 4 Sept.

Andrew Bagdasarov, 64; director of the U.S.S.R. Institute of Hematology and Blood Transfusion and a member of the Soviet Academy of Sciences.

Philip P. Calvert, 90; emeritus professor of zoology at the University of Pennsylvania; 23 Aug.

Fay-Cooper Cole, 79; emeritus professor of anthropology and founder of the department at the University of Chicago; department chairman from 1929 to 1947; 3 Sept.

John R. Freeman, 65; metallurgical consultant and retired vice president in charge of research at Anaconda-American Brass Company; 2 Sept.

Walter Horning, 69; forestry expert and adviser to the director of the Interior Department's Bureau of Land Management since 1949; 5 Aug.

Aaron S. Levin, 65; surgeon who specialized in industrial medicine and geriatrics; 23 Aug.

J. Heng Liu, 71; surgeon and president of the Red Cross Society of China; first Minister of Health of the Republic of China; 26 Aug.

Malcolm C. Moore, 60; chemist and manager of the Hercules Powder Company's technical personnel development section; 1 Sept.

R. Henry Morris III, 64; chemical engineer and retired special assistant for industrial liaison to the director of the U.S. Department of Agriculture's Eastern Utilization Research and Development Division, Wyndmoor, Pa.; 22 Aug.

Evan C. Noonan, 49; chief of the physical chemistry division of the Naval Ordnance Laboratory's chemistry research department, White Oak, Md.; 23 Aug.

H. P. Robertson, 58; member of the President's Science Advisory Committee, and professor of mathematical physics at California Institute of Technology; 26 Aug.

D. E. Robinson, 38; engineer in the Oak Ridge National Laboratory's engineering and mechanical division; 6 Aug.

Henry S. Sharp, 55; chairman of mathematics at Purdue's Calumet extension and former commandant of the U.S. Coast Guard Academy; 7 Aug.

Clarence A. Shelton, 59; geodesist and chief of the Coast and Geodetic Survey's horizontal control section; 4 Aug.

Harry C. Storrs, 75; psychiatrist and retired superintendent of the Letchworth Village (N.Y.) state school for retarded children; 25 Aug.

Morris W. Travers, 89; emeritus professor of physics at University College, Bristol, England; 25 Aug.

Elmer M. Ward, 59; engineer and assistant director of the National Academy of Sciences Highway Research Board; 27 Aug.

Egypt's Pyramids

Early Egyptian literature barely mentions the pyramids. Can research fill the void?

John D. Cooney

The pyramids of Egypt, perhaps not the most beautiful buildings of antiquity, have inspired a literature of formidable extent in the last century and a half. This commenced at the very beginning of the 19th century, and by 1842 one of the basic works had appeared; by the close of the century the imaginative nonsense of the pyramid mystics had come out. In our century great monographs on individual pyramids, works of the greatest importance, have been numerous. In addition to these scholarly works and the many articles on specialized aspects of the pyramids, there have been several books written primarily with the purpose of coordinating scattered information and making it available and interesting to the general reader. Chief among these have been the publications of Grinsell, of Lauer, the great specialist on the Step Pyramid, and, in particular, the very comprehensive book by Edwards of the British Museum.

The most recent addition to this last and small group carries the classically simple title **The Pyramids** (University of Chicago Press, Chicago, Ill., 1961. 260 pp. $5.95). It is written by one of Egypt's foremost scholars, Ahmed Fakhry, whose long career in Egyptian archeology well qualifies him to undertake an exposition of what certainly were the greatest architectural and engineering projects of antiquity.

While the sheer bulk of the pyramids has inevitably directed interest toward their material aspects, an absorbing field, their religious, economic, sociological, and artistic implications are of even greater interest. Unfortunately for us, knowledge of these aspects rests largely on inference and speculation, for Egyptian literature barely mentions the pyramids and the very few references that exist are so incidental and vague that they tell us nothing. The first reference of any substance is by the chatty Herodotus in the 5th century B.C., limited in context and inaccurate but interesting and valuable as the first account. Probably no amount of research will ever fill this void of silence.

Fakhry presents the pyramids in chronological or historical sequence, commencing with the famous Step Pyramid of Dynasty III, the beginning of that great period which continued through Dynasty IV, which originated the pyramid as an architectural form, developed it into a setting for the complex rites due to the deceased divine king, and, having reached its climax in Dynasty IV—as so many elements of Egyptian culture did—rapidly declined in Dynasties V and VI. These dynasties collectively are called the Old Kingdom and cover roughly the period from 2780 to 2280 B.C. Almost 80 percent of the book is devoted to this time, and with justification, for though pyramids continued to be built in Egypt for another six or seven centuries, they never rivaled the great ones of the early period.

Establishing Identity

Among the mightiest of the pyramids are those of Dahshur, the North and South pyramids which Sneferu built at the very beginning of Dynasty IV. Together they represent a mightier effort in one lifetime than the Great Pyramid of Giza which was the work of Sneferu's son Cheops. The South or Bent Pyramid (see Fig. 1), set in romantic isolation, is for some reason one of the most impressive buildings in Egypt. For years it was believed to be a transitional form intermediate between the Step Pyramid and the slightly later true pyramid. The supposition was logical, but the excavations of the late Abdel Salam Hussein at this pyramid in 1946 proved, in his opinion, that the change in angle was necessitated when the architect realized that the original plan would place a crushing weight on the central chambers. Fakhry, on the other hand, suggests that the change in plan was due to the necessity for completing the pyramid in haste, perhaps because of the death of the king. Hussein was convinced that the intact burial chamber still existed in the complex interior and concentrated all his energies on locating it. At that time the identity of the builder was still unknown, and for historical purposes it is well to record that this point was first established by W. Stevenson Smith one morning early in 1947 when we visited the site together. While the interior of the pyramid was being torn apart to locate the chamber no one noticed quarry inscriptions on several of the stones removed to the desert as obstructions. It was Smith who noticed and read the name of Sneferu, thus settling a long-standing puzzle.

An interesting and useful feature of this book is the mention, almost a listing, of the pyramid areas yet to be excavated. In fact, almost no site in Egypt has ever been thoroughly excavated, but one is inclined to suppose that a unit as compact as a pyramid and its enclosure would be easy enough to uncover. Fakhry constantly mentions the unexcavated areas, and some future excavator could well use this work as a guide to excavation in Egypt. The North Pyramid at Dahshur, the first true pyramid in Egypt, is indeed identified, but its temples are still covered with sand and so are unknown. Both pyramids at Dahshur and the Great Pyramid at Giza have magnificent and complex interiors actually built within the mass of the pyramid itself. With the exception of a very few other examples, the Egyptian pyramid was not usually a functional building. Whatever its origin—an unsettled question—it was in most cases a solid mass built over a tomb chamber cut in the bedrock. The opulent halls of Sneferu and his son Cheops were beyond the means of their successors.

When the use of the pyramid as the royal tomb was resumed in the Middle Kingdom, a great change took place. The impressive, solid, stone construction typical of the early pyramids was abandoned, one suspects for financial rea-

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sons, for a shoddy series of cross walls filled in with sand, rubble and even mud brick. The tradition of a fine outer casing in limestone was retained, and so the effect was fine—for a time. But combined with this wretched construction the architects used great imagination, effort, and the finest stones in designing the novel interiors usually built into the rock under the pyramid. Clearly, they were attempting to make the burial chambers with their great wealth inaccessible to thieves. These efforts for security imply that the earlier pyramids had already been robbed. It is curious that, with their constant fear of robbery after death, the Egyptians never sublimated their funerary beliefs into something unsubstantial and so made their burials unattractive to thieves. In turn one wonders if the omnipresence of tomb robberies indicates a skepticism among the Egyptians which too has found almost no expression in their literature.

At all events the pyramid went out of use as a royal tomb early in Dynasty XVIII, perhaps about 1575 B.C., and was replaced by the equally costly but hidden rock-cut tomb, presumably because the futility of the pyramid was all too obvious. In the 8th century B.C. the pyramid was copied far up the Nile in the barbarous land of Cush where it long survived as a royal tomb. In Egypt, however, the form was never revived, so far as we know, which is strange, for in Dynasties XXV and XXVI there was a general adulation of the past with widespread copying or working in the spirit of earlier ages. Perhaps these late descendants of the pyramid builders did not want to duplicate these unique structures, but the chances are that they lacked the resources to do so.

Charge for Posterity

A brief paragraph (page 213) carries a wonderful suggestion which some future generation will surely carry out. Here Fakhry suggests that it would be well to dismantle the pyramid of Amenemhet I at Lisht, which is known to be constructed, at least in part, from reliefs and inscriptions taken from the great Dynasty IV temples and monuments at Giza and elsewhere. The idea is sound, for the pyramid is mediocre and in poor condition, and the recovery of these early reliefs would surely enlarge our knowledge. Whether, in using these blocks which entailed at least great damage to ancient buildings, Amenemhet was motivated by greed or, as is more probable, hoped to gain something magical or spiritual from contact with the work of his distant predecessors is a matter of opinion. The Egyptian Expedition of the Metropolitan Museum of Art did indeed extract some of these reliefs from the pyramid years ago with rich results; the results are soon to be published. The registration and storage problems involved in reverse construction of a pyramid are so gigantic that most museum men will willingly leave the project to posterity.

The drawings and photographs in this book are admirable and numerous, adding greatly to its interest and utility. Some of the photographs are of unusual and rarely reproduced views of pyramid interiors, the best substitute for those who can never get to Egypt. They give a feeling of the gigantic scale and fine construction of these great monuments of early Egypt, which still impress and fascinate men. The treasures they, or more probably their related temples, once held are forever lost to us, with the exception of stray scraps—a magnificent gold uraeus of Dynasty XII, dropped by thieves and rarely reproduced today; two caches of jewelry from the same period which alone have established that time as the apex of all jewelry design; a few wooden items; and a fair number of sculptures.

On Crowning Kings

Books, like individuals, rarely achieve perfection and, in any case, a review is not considered "serious" unless it includes some critical comment. Most of

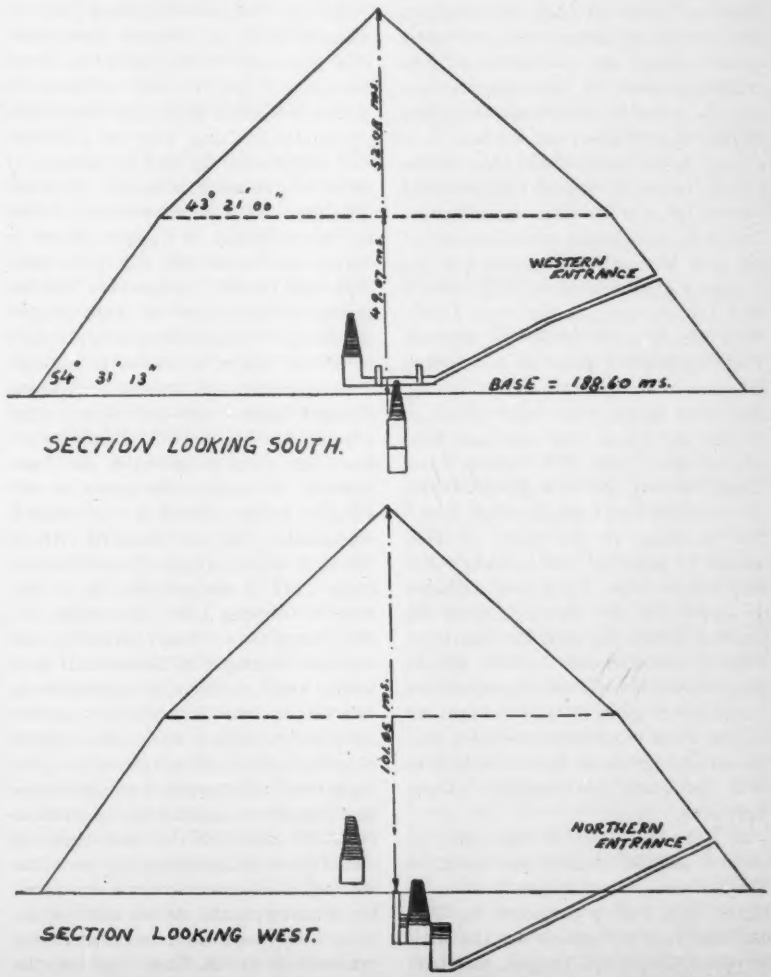

Fig. 1. Dimensions and angles of the Bent Pyramid at Dahshur. [Hassan Mustapha]

the errors in this book are trivial, but a few are of importance and should be corrected in any subsequent edition. On page 12 there occurs one of the classic editorial errors of Egyptological literature, here enlarged and expanded to Miltonic proportions. This is the "correction" of *Nomarch* to *Monarch*. Ancient Egypt was divided into a series of districts or provinces which the Greeks called "nomes," the governor of one of these nomes being a "nomarch." Since this rare noun is almost never included in English dictionaries, it has become a matter of course for editors to smile and transpose the first and third letters of this noun, thus elevating a provincial governor to royal rank. In the present instance the editorial boner has created a new king, Dhutihotep, to add to the already complex list of kings.

The reference on page 27 to two small reliefs in the Metropolitan Museum as "among the best specimens of sculpture" from the reign of Zoser (Dynasty III) is no longer valid, for these unusual pieces are now believed to be archaizing work of late date. In any case the reliefs in Turin from Heliopolis of the reign of Zoser are far finer. It is a pity that the romantic idea of the Libyan origin of one of Cheops' chief queens (page 125) must be adversely criticized. A splendid representation of her with blue eyes and blond hair led the great Reisner to develop the theory of a Libyan strain in the royal family from which much could be inferred. That imaginative piece of scholarship has been thoroughly eradicated by W. Stevenson Smith some years since, to his and our regret. One must also hesitate to agree (page 237) that in Cush (Sudan) during the New Kingdom "local industries had reached a high level." The paintings in the tomb of Huy quoted as proof of this actually show very clearly that Cush was expected to supply the raw materials only; the finished objects depicted are clearly of Theban manufacture. Indeed, despite long colonization by the Egyptians and considerable aping of their culture, the land of Cush remained remarkably provincial and produced almost nothing to rival the great craftsmanship of the Egyptains.

It is curious that on page 242 the learned author restates an error of identification from the early days of Egyptology. Far to the south in Cush near the Fourth Cataract are the similar sites of Zuma and Tangasi, each with a considerable number of earth mounds varying greatly in size and height and interspersed with circular pancake-like burials. The early travelers described them, as does Fakhry, as pyramids and even Lepsius went along with this description. And from a distance these mounds do give the impression of ruined pyramids, not unlike the remains of brick pyramids of the Middle Kingdom. Even a cursory inspection explodes the pyramid theory, for the mounds are of earth, artificially constructed, with a surface scattering of local stones of natural shape placed there to reduce surface erosion. Excavations at similar sites, mainly in northern Cush, during the past three decades give ample basis for dating these mounds to the X-group people. Excavations at Tangasi by the Sudan Antiquities Service in 1953, while disappointing so far as finds were concerned, did show conclusively that these structures had no connection with pyramids.

Several broader criticisms can be made of this work. A more comprehensive treatment of the royal tombs of Dynasties I and II would be useful. It is true that these structures were never pyramidal, but they were the predecessors of the pyramid, and the account of them in this work is hardly adequate. The discovery in recent years of a series of vast mastabas at Saqqara North is barely mentioned, and the controversy over their identity is passed by. The distinguished excavator of these mighty structures, Walter Emery, believes them to be the tombs of the earliest kings. His arguments are strong, and many scholars agree with his ideas; other scholars are not convinced and, in any case, the excavations have not been finished. In a very few cases the description of the interior of a pyramid is inadequate; that of Sesostris III at Dahshur is an example. The references (page 221) to the monuments of this king at Abydos seem inaccurate, for they mention a "small pyramid and temple." A temple of Sesostris III does indeed exist at this site, apparently in relation to the mysterious rock-cut structure, perhaps a cenotaph, which is of great interest as a variant form of royal tomb. The pyramid presumably is that usually, if uncertainly, ascribed to early Dynasty XVIII, and here it would have been instructive to quote the text of Ahmose, which seems to refer to this pyramid. Much more of interest could have been recorded of the pyramid fields of Cush and of the splendid finds that have come from them. These exotic constructions were excavated by Reisner and have been splendidly published by Dunham. With these great publications at hand it would seem that one could dispense with the adventurous works of Budge.

One defect, obviously no fault of the author's, is that the text has been so extensively edited, presumably in a mistaken ideal of grammatical accuracy, that Fakhry's vivid personality is not evident. He is an ebullient, witty, and vivacious individual, and one wishes that the editors had allowed more of his style to prevail, grammar notwithstanding.

Tursiops-side-down World

Porpoise and Sonar. Winthrop N. Kellogg. University of Chicago Press, Chicago, Ill., 1961. 177 pp. Illus. $4.50.

Man and Dolphin. John C. Lilly. Doubleday, Garden City, N.Y., 1961. 312 pp. Illus. $4.95.

The authors of these two books have one common purpose, which they display with undisguised enthusiasm. It is to convey the fascination, privilege, mystery, and sense of high adventure of their own apparently quite unrelated and separately conducted researches during the past decade on *Tursiops truncatus*, the shallow-water or bottlenose dolphin. But how differently they do it.

Both books are white-hot from the furnace of experience. Both authors are concerned to emphasize (quite justifiably) the importance to defense projects of their remarkable demonstrations that these dolphins emit underwater sonic impulses at frequencies up to 200 kilocycles per second and that at the least they use some part of these sounds as echo-ranging signals for navigation and orientation. Kellogg writes selflessly with apposite tables, diagrams, figures, experimental detail, careful index, and references, in the best style of a descriptive scientific text intended for the nonspecialist reader. Lilly's book is as revealing about man—not any man, but one man, John C. Lilly—as about dolphin. It is undoubtedly one of the frankest and most egotistical accounts of a research project ever placed before a sensation-loving public. Many of his numerous photographs seem more suited to the family album than to an

account of scientific discovery. But these personal idiosyncrasies do not hide a great deal of valuable behavioral observation, psychological insight, surgical competence, and complex experimentation based on already well-established techniques, including cerebral probing. Yet in being so frank about his early failures, his treatment of the dolphins, and his personal sacrifices, it may be questioned whether he has not done his cause a disservice. It may be noted that Kellogg has deliberately eschewed vivisection with his dolphins, preferring to work with the whole mammal.

A substantial part of both sets of investigations was based on training procedures similar to those which have been used with other animals, such as chimpanzees, dogs, rats, and fish. It seems that dolphins, like dogs and humans, have temperaments, and that account must be taken of these, as Pavlov did, when interpreting the results. Derivative support for the validity of their conclusions on sonar ranging and dolphin vocalization is sought by both authors in the large size of the eighth cranial nerve and the complexity of its central connections. Comparable though much simpler elaborations occur also in some fishes, for example, Triglidae and Mormyridae, and suggest that these may repay further study along these lines. Subjectively, the dolphin's vocalizations for finding and recognition in circumstances where visual localization is thought to be impossible are described as pings, clicks, or creaks. There is a further wide range of vocalizations which Lilly regards as a kind of "dolphinese" language. Kellogg confines himself to his rigid examination of the dolphin's sonar system, but Lilly goes into vivid speculation, expressed graphically and with extreme self-confidence, that these dolphins, through their language and because of the known great size and complexity of their brains, may be the first nonhumans with whom man may learn to communicate. Here his book is more reminiscent of Algernon Blackwood's imaginative fantasies than of legitimate scientific inference; but—to quote his own expression—he "sticks his neck out" so deliberately and provocatively that it would be a pity to harm it, and it should indeed be taken as a warning, though perhaps not in the sense he intends.

H. O. BULL
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Vistas of Anthropologists

They Studied Man. Abram Kardiner and Edward Preble. World, New York, 1961. 287 pp. $5.

Indeed, they studied man, and from different points of view. This diversity of viewpoint is considered very desirable in this day when interdisciplinary (not multidisciplinary) studies are being advocated. Here, however, we see these representatives of the several disciplines studying man in their own ways, and their efforts are described as seen through the professional eyes of two scholars trained in, and practicing, psychiatry.

The authors state that their interest is not historical but that they "have attempted to relate the seminal hypotheses of the few great innovators in the development of a 'science of man' to the ethos of the times and to the specific lives of these innovators." Their innovations are seen by Kardiner and Preble as cultural responses to "collective interests and needs," but also as "the products of idiosyncrasies and genius."

The word "They" in the book's title refers to the nine scholars Kardiner and Preble chose to discuss. These include Darwin, the evolution-minded naturalist, and Herbert Spencer, the English philosopher who championed such theories as that of orderly social evolution and social functionalism. Tylor, the "founder of modern anthropology," emphasized the psychic unity of man and the concept of animism in understanding primitive religions. In regard to Sir James Frazer, author of the monumental work, *The Golden Bough*, I am inclined to agree with the authors when they say "It is not easy to determine Frazer's reputation in the history of anthropology." The principal influence of the French sociologist, Emile Durkheim, was in terms of his basic functional approach in the study of culture and society. Franz Boas, trained as a physicist, "chose instead to study man." The authors point out, very correctly, that Boas' "methods and attitudes" have shaped the course of modern anthropology, particularly in the United States. Bronislaw Malinowski, also a functionalist, was a very controversial figure because he "did not simply disdain the usual customs and proprieties, he took a positive pleasure in violating them." Alfred Kroeber became, in fact, the dean of American anthropologists. He was an accomplished field ethnologist and an authority on the theoretical nature of culture and culture change. Ruth Benedict, at once a poet and a scientist, was basically a functionalist, who emphasized the cultural configuration approach. I feel it can be fairly said that the work of Sigmund Freud had little direct effect on cultural anthropology. Rather, there have been strong indirect influences based largely on the concepts of the basic personality and the relation of psychodynamics to culture.

The authors suggest that there may be disagreement regarding "our selection of anthropologists." While each one of the scholars discussed had a strong influence on the development of anthropology, they were not all anthropologists. I wonder why such men as Lewis H. Morgan and Radcliffe-Brown were omitted.

One excellent feature is the biographical sketch, given at the beginning of the discussion, of each of the scholars. The book will be valuable to those interested in the social sciences, both students and laymen.

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Broad-Brush Picture

Pioneer Microbiologists of America. Paul F. Clark. University of Wisconsin Press, Madison, 1961. xiv + 369 pp. Illus. $6.

Pioneers consists of 18 chapters arranged in five sections—Foundations of Early Bacteriology (4 chapters); The Atlantic Seaboard (8); The Central Valley (2); Our Western Lands (2); and Perspective (2)—plus 23 pages of bibliographic notes and an index of almost 1100 entries. Photographs of 37 of the many bacteriologists discussed utilize ten pages; the photographs are the more interesting because the age of the individual at the time the photograph was taken is given. Thus, the eager boyishness of Novy at 35 contrasts with the maturity of Vaughan at 59—two individuals, Thom and Karl Meyer, are ageless. Following 79 pages on the beginnings of bacteriology (abroad and in America) and on epidemiology and epidemics, the author discusses pioneer bacteriology in the East, including the contributions made

by workers in federal agencies. The section on the central valley recalls early times in Michigan, the Chicago area, Wisconsin, and briefly in Ohio, Indiana, Minnesota, Iowa, Kansas, and Texas. The section on our western lands includes the Rocky Mountain area and California and the coastal area. Chapter 17 is a chronological review of societies and journals—the means of communication. The "Epilogue" permits the author to "look out his laboratory window" and philosophize a bit.

Clark writes with charm and with an accuracy based on study of the records and personal knowledge of most of the "pioneers." His portrayals are sympathetic, concise, and interesting. The cut-off date is 1919, but in some instances, which he must be forgiven since he is writing history and not a card file, he goes much beyond that date—for example, in the discussion of homologous serum jaundice induced by a virus in yellow fever vaccine (1941, 1942).

Very few worthy personalities are omitted. Some familiarity with the material involved leads me to say this volume is a remarkably accurate, interesting, and valuable book which should be read by all bacteriologists. More such books should be written in this and in other fields. It is one thing to write a great man's biography but quite another to take a whole era and to set into its record the trends, the actors, and the accomplishments—and to do this in proper perspective and accurately. This Clark has done.

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Essays on Psychiatry

Lectures in Psychiatry. Pittsburgh Bicentennial Conference. Henry W. Brosin, Ed. University of Pittsburgh Press, Pittsburgh, Pa., 1961. x + 361 pp. $7.50.

This volume is a compilation of lectures given at a conference on experimental psychiatry at the Western Psychiatric Institute and Clinic in March 1959. Essentially the volume amounts to essays on various topics by well-chosen experts. Accordingly, the book is far more readable than other published symposia based upon edited tape recordings of lectures.

All of the lectures are well done, and together they present an excellent overall view of the principal avenues along which research in modern psychiatry is progressing. The reader, depending upon his scientific biases, will enjoy some of the lectures more than others, but he can profit from all of them.

Examples of the content of the volume are as follows: discussion of the interaction of genetic and experiential variables in child development by John D. Benjamin; a review of the history, development, and implications of psychopharmacology by Joel J. Elkes; a conceptual analysis of the organization of human behavior by David McK. Rioch; and an account of recent developments in cybernetics by Warren S. McCulloch.

I recommend this book highly to anyone interested in the behavioral sciences.

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New Books

Biological and Medical Sciences

Advances in Tuberculosis Research. vol. 11. Hans Birkhauser, Hubert Block, and G. Canetti, Eds. Karger, New York, 1961. 279 pp. Illus. $18.

Adaptation. Bruce Wallace and Adrian M. Srb. Prentice-Hall, Englewood Cliffs, N.J., 1961. 124 pp. Illus. Paper, $1.50.

Animal Diversity. Earl D. Hanson. Prentice-Hall, Englewood Cliffs, N.J., 1961. 128 pp. Illus. Paper, $1.50.

Biotic Principles. Herbert L. Stahnke. Merrill Books, Columbus, Ohio, 1961. 671 pp. Illus. + plates.

Canadian Cancer Conference. Proceedings of the fourth Canadian Cancer Research Conference, 1960. vol. 4. R. W. Begg, Arthur Ham, C. P. Leblond, R. L. Noble, and R. J. Rossiter, Eds. Academic Press, New York, 1961. 477 pp. Illus. $12.

Coffee. Botany, cultivation, and utilization. Frederick L. Wellman. Hill, London; Interscience, New York, 1961. Illus. $13.

Comparative Animal Physiology. C. Ladd Prosser and Frank A. Brown, Jr. Saunders, Philadelphia, Pa., ed. 2, 1961. 697 pp. Illus. $15.50.

Ergebnisse der Bluttransfusionsforschung. vol. 6. R. Stahl. Karger, New York, 1961. 396 pp. Illus. $16.

The Eucalypts. Botany, cultivation, chemistry, and utilization. A. R. Penfold and J. L. Willis. Hill, London; Interscience, New York, 1961. 571 pp. Illus. + plate. $13.25.

Formation and Breakdown of Haemoglobin. C. P. Stewart, Ed. Elsevier, New York, 1961 (order from Van Nostrand, Princeton, N.J.). 71 pp. Illus.

Gnetum. Botanical Monograph No. 1. P. Maheshwari and Vimla Vasil. Council of Scientific and Industrial Research, New Delhi, India, 1961. 154 pp. Illus. + plates.

Heredity. David M. Bonner. Prentice-Hall, Englewood Cliffs, N.J., 1961. 126 pp. Illus.

The Merck Manual of Diagnosis and Therapy. Charles E. Lyght, Ed. Merck Sharp and Dohme Research Laboratories, Philadelphia, Pa., 1961. 1923 pp. Illus.

Oncogenic Viruses. Ludwik Gross. Pergamon, New York, 1961. 404 pp. Illus. $12.

The Ontogeny of Insects. Acta Symposii de Evolutione Insectorum, Prague 1959. I. Hrdy, Ed. Czechoslovak Acad. of Sciences, Prague; Academic Press, New York, 1960. 406 pp. Illus. $10.

Pharmaceutical Analysis. Takeru Higuchi and Einar Brochmann-Hanssen, Eds. Interscience, New York, 1961. 863 pp. Illus. $28.50.

Physiology of Reproduction and Artificial Insemination of Cattle. G. W. Salisbury and N. L. VanDemark. Freeman, San Francisco, 1961. 651 pp. Illus. $12.50.

Saliva and Its Relation to Oral Health. D. Ofonsky. Univ. of Alabama Press, University, 1961. 809 pp. $12.

Samson Wright's Applied Physiology. Cyril A. Keele and Eric Neil. Oxford Univ. Press, London, ed. 10, 1961. 562 pp. Illus. $13.50.

Some Aspects of Life in Fresh Water. Edward J. Popham. Harvard Univ. Press, Cambridge, Mass., 1961. 135 pp. Illus. $2.25.

Translocation in Plants. A. S. Crafts. Holt, Rinehart, and Winston, New York, 1961. 192 pp. Illus. $5.

Vertebrate Speciation. W. Frank Blair, Ed. Univ. of Texas Press, Austin, 1961. 658 pp. Illus. $8.50. Twenty-one papers covering isolating mechanisms, evolution of behavior, polymorphism and polytypic species, population dynamics, and age and origin of species. The papers were read at a 5-day conference held in October 1958 at the University of Texas.

General

Ancient, Medieval, and Modern Christianity. Charles Guignebert. University Books, New York, 1961. 539 pp. $7.50.

Divinity and Experience. The religion of the Dinka. Godfrey Lienhardt. Oxford Univ. Press, New York, 1961. 336 pp. Illus. $6.75.

Emotion. A comprehensive phenomenology of theories and their meanings for therapy. James Hillman. Northwestern Univ. Press, Evanston, Ill., 1961. 328 pp. $6.

Intervention and the War. Richard H. Ullman. Princeton Univ. Press, Princeton, N.J., 1961. 376 pp. Illus. $7.50.

Physicist and Christian. William G. Pollard. Seabury Press, Greenwich, Conn., 1961. 191 pp. $4.25.

Science and the New Nations. Ruth Gruber, Ed. Basic Books, New York, 1961. 329 pp. $6.50.

Science Awakening. B. L. Van der Waerden. Translated by Arnold Dresden. Oxford Univ. Press, New York, 1961. 306 pp. Illus. $7.50.

Reports

Acquired Tolerance of Leaves to Heat

Abstract. When bean, cowpea, cucumber, fig and tobacco leaves were heated 15 to 30 seconds at 50°C, 12 to 48 hours later they tolerated a temperature of 55°C up to three times as long for the same degree of heat injury as did leaves which were not previously heated.

The phenomenon of acquired tolerance to cold has been clearly demonstrated in higher plants (*1*), acquired tolerance to heat has been clearly demonstrated in microorganisms and higher animals (*2*), but acquired tolerance of higher plants to heat has apparently not been reported.

Entire plants, twin leaves, half leaves, or leaf pieces of bean (*Phaseolus vulgaris* L. var. Pinto), cowpea [*Vigna sinensis* (Torner) Savi var. Blackeye], cucumber (*Cucumis sativus* L. var. National Pickling), fig (*Ficus carica* L. var. Calimyrna), and tobacco (*Nicotiana tabacum* L. var. Turkish) were immersed in water for various times at 45° to 55°C, and at various intervals after the first treatment, these plants and appropriate controls were subjected to 55°C for various periods. The heat tolerance of the species differed, being least with bean and greatest with fig. With bean the dosage required for 50-percent injury (50-percent reduction in green weight) was about 400 sec at 45°C, 80 sec at 50°C, and 16 sec at 55°C though these values varied with time of day, age of plants, and undetermined causes. Of these three temperatures, the optimum for the development of acquired heat tolerance (AHT) was 50°C, and the optimum time period for a single treatment was about 25 sec. Heat tolerance was tested by immersing the treated and nontreated leaves in water at 55°C for 5 to 30 sec. Injury was recorded after 2 days on a decimal scale of 0 (no injury) to 10 (death); it was shown that this rating of injury was well correlated with injury as based on green weight. The dosage required for 50-percent injury (ED_{50}) was observed directly or by interpolation on a standard curve relating heat dosage to injury. The ED_{50} for the treated leaves divided by the ED_{50} for the control leaves is the index of acquired heat tolerance (IAHT). Values less than 1 would indicate cumulative injury, values of 1 would indicate no effect, and values greater than 1 would indicate acquired heat tolerance.

In a typical twin leaf comparison, one primary unifoliate leaf of a pinto bean plant 10 days from seeding was heated 25 sec at 50°C at 5 P.M. on 11 May. At 7 A.M. on 13 May this leaf and the twin leaf control were heated 12 sec at 55°C. Two days later the control leaf was almost dead (injury rating, 9), and the treated leaf showed only slight injury (injury rating, 1). The dosage response curve for injury to control leaves follows approximately the relation

$$I = 21.7 \log x - 22$$

where I is the injury and x is the number of seconds of heat dosage at 55°C. Thus, in the above comparison the ED_{50} for the control leaf was 8.5 sec, and the ED_{50} for the treated leaf was 18.5 sec. The index of acquired heat tolerance was therefore $18.5/8.5 = 2.2$. A similar response to multiple treatments is illustrated in Fig. 1. The data and conclusions of this study are based on 370 such paired comparisons.

Acquired heat tolerance from a single treatment of 25 sec at 50°C was barely apparent when the injury treatment followed the treatment by 10 min (that is, the index was slightly but significantly greater than 1), was greatest at about 24 hours (the index ranged from 1 to 3.5), and lasted until at least 72 hours after treatment. Thus the AHT effect lasted more than 10^4 times as long as the treatment.

Acquired heat tolerance was demonstrated with bean, cowpea, cucumber, fig, and tobacco. Only with bean was acquired heat tolerance demonstrated with entire plants. The other species were tested only as leaves. With primary leaves of bean and cowpea and with cucumber cotyledons, acquired heat tolerance was demonstrated with twin leaves. With secondary leaves of cucumber, fig, and tobacco, acquired heat tolerance was demonstrated with half leaves and even smaller parts of leaves. The greatest degree of acquired heat tolerance (IAHT = 3.1) from single treatments so far has been with fig.

With bean and cowpea, acquired heat tolerance has been demonstrated with as many as 15 successive heat treatments of the same specimens over periods as long as 4 days, but for the dosages so far studied, successive treatments after the first one have raised the index of acquired heat tolerance only slightly.

Only two trials were made with plant pathogens, and single AHT treatments have not yet been tested with them. Leaves inoculated with bean rust (the uredinial stage of *Uromyces phaseoli* in living beans) were treated 10 sec at 45°C at 109, 119, 134, 144, 156, 167, and 181 hours after inoculation, and

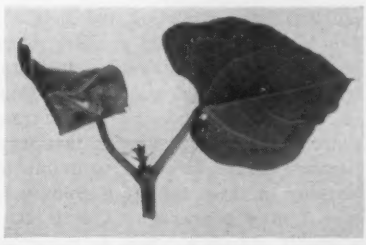

Fig. 1. Acquired heat tolerance in bean. The right leaf was treated for 20 sec at 50°C at 6 P.M. on 28 April, 7 A.M. on 29 April, 7 A.M. on 30 April, 6 A.M. on 1 May, and 8 P.M. on 1 May. On 2 May both leaves were heated for 15 sec at 55°C at 8 A.M. Photographed 10 A.M. on 4 May. The right leaf shows acquired heat tolerance and the left leaf (killed) shows severe heat injury.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

these leaves and control leaves were treated for 4, 6, 8, 10, or 12 sec at 50°C at 205 hours after inoculation. The ED_{50} for the treated rust was 8 sec at 50°C, and for the control rust it was 5.5 sec at 50°C, as indicated by continuation of mycelial growth and spore production.

It is believed that acquired heat tolerance may be an important factor in the ecological heat tolerance of plants and their pathogens (*3*).

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3. This research was supported by a grant (G 9820) from the National Science Foundation.

29 May 1961

Thermal Reinforcement and Thermoregulatory Behavior in the Goldfish, Carassius auratus

Abstract. Goldfish in a warm environment can cause a small drop in the temperature of their environment by pressing a lever. The fish regulate the temperature of their environment, keeping the temperature between 33.5° and 36.5°C most of the time.

The rate of activity and metabolism of poikilotherms is largely determined by the temperature of their environment. Yet thermal adaptation in these animals tends to reduce the effects of temperature and poikilotherms can also change their body temperature by moving from one environment to another.

The process of temperature selection has been investigated in a number of poikilotherms, including the goldfish. Fry (*1*) has found that goldfish, when placed in water containing a temperature gradient, spend most of their time in water within a certain temperature range. This finding suggests that temperature might be used to reinforce learning in these fish. If a goldfish is placed at a temperature that is considerably different from its preferred temperature, will it perform some arbitrary response in order to bring the temperature of its environment closer to its preferred temperature? Furthermore, if temperature change can be used as a reinforcement, will the fish regulate its body temperature by regulating the temperature of its environment? Weiss and Laties (*2*) have shown that the albino rat, when placed in a cold environment, will press a lever for heat reinforcement. No similar experiment has been performed with a poikilotherm. In the experiment presented here, it is demonstrated that goldfish will work to produce certain temperature changes in their environment, and that, when given the opportunity to control their body temperature, they will do so to a certain extent.

The experimental apparatus is shown in Fig. 1. A small goldfish (3 to 8 g) was placed in a 1-pint container of water. This container rested in a constant-temperature water bath. During training the bath was initially at a temperature of 24.5° ± 0.5°C. The home container of the fish was kept at 23° ± 1°C. The fish was given 10 minutes to adapt to the experimental container, and then the temperature of the water bath was gradually raised to 41°C over a period of about ½ hour. The lethal temperature for these goldfish is approximately 41°C (*3*). When the temperature in the experimental container reached between 30° and 35°C, training was begun. Measured amounts of cold water were introduced into the container at irregular intervals. Each cold reinforcement consisted of a 1-sec flow of cold water (2 to 3 ml) from the distilling tube mounted above the container (see Fig. 1) and produced a transient drop in temperature of approximately 0.3°C. A small light bulb mounted above the container was lighted during the 1-sec reinforcement period. Each fish received approximately 50 reinforcements in each of two training sessions.

In the third session, the lever was placed in its appropriate position, and the lever target was located behind the hole in a Plexiglas lever guard (Fig. 1). In order to actuate the lever, the fish had to insert its head through the hole and push at the target. The lever guard prevented chance operation of the lever by the swimming movements of the fish. When the temperature rose to above 30°C, training for lever pressing was begun. The method of "successive approximations" was employed (*4*). In this method, the reinforcement is first given whenever the animal is near the lever, then when the animal touches the lever, and finally only when the animal presses the lever. Most fish learned to press the lever within 2 hours after the onset of training. Seven small goldfish were trained.

The fish were then placed in a "titration" situation. The temperature of the water bath gradually rose and leveled off at 41°C. By pressing the lever for squirts of cold water, the fish could lower the temperature in its container. The temperature was maintained at 41°C for the entire session, once it had reached this level. Thus, a constant temperature stress was provided for the fish.

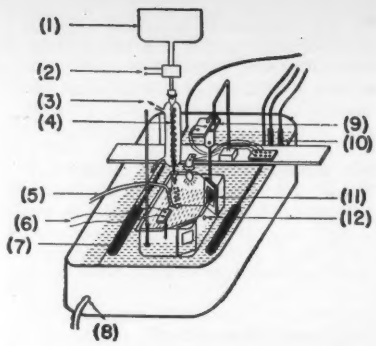

Fig. 1. Device for the study of regulatory behavior in the goldfish. 1, Water supply; 2, electric valve; 3, cold water; 4, distilling tube; 5, air line; 6, wires from thermistor; 7, heater; 8, "constant level" hole; 9, lever assembly; 10, thermostats; 11, lever guard; 12, "constant level" hole.

Two procedures were employed in experimental sessions. In the first procedure, the temperature of the experimental container was raised to 38°C before the fish was permitted access to the lever; the fish was then given access to the lever for 2 hours. The lever-pressing responses and temperature in the container were recorded continuously

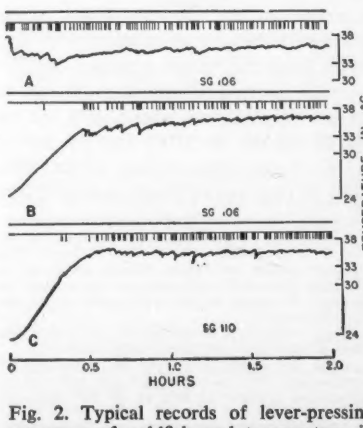

Fig. 2. Typical records of lever-pressing responses of goldfish and temperature in the container. *A*, Fish drives down environmental temperature. *B* and *C*, Fish prevent the temperature from rising above 35° to 36°C.

throughout the 2-hour sessions. As is shown in Fig. 2*A*, a typical record, the fish almost immediately drove the temperature down from 38°C to approximately 35°C. In almost every 2-hour session, the fish showed a burst of responses when the lever was initially made available. Within a few minutes the temperature was brought down to the level later maintained. The fish very rarely allowed the temperature to rise above 36.5°C and rarely pushed it down below 33.5°C. The temperature remained with this 3-degree range almost all of the time. The maintained temperature of about 35°C in this experiment is much higher than the value determined by Fry (*1*) for temperature selected by goldfish in a thermal gradient (27°C for fish adapted at 25°C or more). It is likely that the fish in this experiment were setting the tank at a maximum comfortable temperature. That is, 35°C may be about the highest temperature at which these fish do not get aversive thermal feedback from their environment.

In the second series of experiments, as soon as the lever was made available at the initial temperature of 24.5°C, the water bath was gradually heated to 41°C over a ½-hour period. Sessions lasted 2 hours from the introduction of the lever. In this situation, fish were able to maintain their tank at a given temperature with much less work than under the first procedure. They were not required to bring the temperature down initially to the selected level. If amount of work is an important variable in controlling thermoregulatory behavior, one might predict that the fish would maintain a lower temperature in the second experiment than in the first.

The results of this second experiment, as shown by the examples in Fig. 2, *B* and *C*, indicate that there is no difference between the temperatures maintained under the two sets of conditions. Typical records for fish SG 106 under both conditions are shown in the figure.

Fish usually did not press the lever much at temperatures below 33°C in the second experimental series. They usually began pressing consistently at approximately the maintained temperature of 35° to 36°C. Some records (Fig. 2*B*) show a gradual upward drift in temperature as the session continues. Others show relatively little drift and very close regulation (Fig. 2*C*).

Control experiments have indicated that the increased activity of the fish at higher temperatures and the slight increase in oxygen tension of the water associated with reinforcement are not important factors controlling thermoregulatory behavior in this situation.

The results of these experiments indicate that the goldfish will regulate its body temperature within certain limits under a constant high-temperature stress. It has been suggested (*5*) that temperature selection in fish can be accounted for as a direct effect of temperature on the locomotion of fish. This study indicates that other factors are involved in temperature selection, since the goldfish will perform an arbitrary response to change the temperature of its environment (*6*).

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6. This investigation was part of a thesis submitted in partial fulfillment of the requirements for the Ph.D. degree by one of us (P.N.R.). The research was supported in part by grants from the National Institute for Neurological Disease and Blindness (B-1941) and the Nutrition Foundation.

17 April 1961

Progressive Ratio as a Measure of Reward Strength

Abstract. Four rats were trained to press a lever on a ratio schedule of reinforcement in which the number of lever presses required on each consecutive run increased by a fixed increment. Both concentration and volume of the reward were varied. Relationships were obtained between reward and deprivation variables and the size of the final completed ratio run.

For many years, experimenters in the field of animal motivation have utilized the obstruction technique as a means of determining the relative strength or "attractiveness" of rewards under various motivational conditions. The technique consists of interposing an obstruction, such as an electrified grid, between the animal and some reward such as food. Initially, the rationale for this procedure was that the greatest intensity of electric current which the animal would cross should correlate with variations in reward and deprivation. Implicit in this line of reasoning is the view that over a broad range of values, the "breaking point" of an animal's behavior should be a good measure of the relative effectiveness of motivational variables. However, due to the great variability in behavior associated with repeated electric shocks, experimenters have been unable to establish a reliable "breaking point." Instead, workers have used the number of crossings of a grid with a constant charge during a fixed period of time as an index of reward strength (*1*). Nevertheless, the repeated use of electric shock results in highly variable data which are particularly difficult to interpret in the case of individual animals.

The experiments reported here were designed to overcome the shortcomings of obstruction methods by using as a measure of reward strength the largest number of responses which an animal will make to obtain a reward. With this technique, a stable "breaking point," which varies reliably with changes in reward and deprivation, can be obtained.

The subjects of these experiments were four albino rats from the colony at the Walter Reed Army Institute of Research. Their weights at the start of the experiment ranged from 250 to 450 g. The apparatus was a modified Skinner box adapted for liquid reward and controlled by a system of relay-operated switching circuits.

After a brief initial period of training to press the lever to receive 0.05 ml of sweetened condensed milk as a reward, the rats were placed on the progressive ratio schedule, which requires that the animal emit an increasing number of responses in order to obtain each reward. The ratios used in these experiments increased by an increment of two, so that the rats were required to emit two responses for the first reward, four for the second, six for the third, eight for the fourth, and so on. Each run of responses in this increasing schedule is called a ratio run. A timer in the circuit was set so that if at any time during the experiment the animal failed to respond for a period of 15 minutes, the session was automatically terminated (*2*).

In the first experiment, sweetened condensed milk was diluted with various amounts of water on different days of the experiment. The order of

presentation was random, and the animals were maintained ad libitum on lab chow and water in the home cage. Figure 1 (top) shows the results of this experiment. The number of responses in the last complete ratio run before the animal failed to respond for a 15-minute period are plotted as a function of the concentration of the milk reward. Each point represents the median of six test sessions. The last point on each curve represents the data obtained when the reward was water alone. As the concentration of sweetened condensed milk declines, the magnitude of the final ratio run also declines. It is interesting to note that even when animals have been maintained ad libitum on lab chow and water, sweetened condensed milk in high concentrations still can function as a relatively potent reward. This is illustrated by the striking difference between the first and last points of each curve.

In the second experiment, the amount of food consumed daily by each rat was regulated so that over a period of 4 to 6 weeks its body weight was gradually reduced to 80 percent of normal. When the rats had reached 80 percent of their normal weight, their food ration was systematically increased so that over a similar time period they were returned to their normal weights. During both of these periods, the testing schedule described above was continued. The concentration of the milk reward was held constant at equal volumes of milk and water. Water was available ad libitum in the home cage. At the termination of the experiment, the data were grouped into 5-percent intervals of weight. The solid lines in Fig. 1 (bottom) show the results of this experiment. Each point represents the median of the data of 9 to 14 sessions. The curves indicate that as the animals' body weights diminish from normal, the number of responses in the final ratio run increases markedly.

The third experiment was carried out in the same manner as the second, except that the volume of the milk reward was increased from .05 to .20 ml. The effects of this increase are shown by the broken lines in Fig. 1 (bottom). The general trend of the .20-ml curves is the same as the .05-ml curves. A comparison of the .20-ml and .05-ml curves indicates a small but rather stable increase in the final ratio run under the .20-ml condition. This increase is most apparent at the higher levels of deprivation.

One may inquire as to what extent these results may reflect an interaction with progressive satiation. Whatever satiation effects may be present are most likely quite small; for, during initial lever-pressing training, it was noted that while deprived of food, each rat ingested 12.0 to 15.0 ml of milk. This is in sharp contrast to the 2.0 to 3.0 ml of milk consumed under comparable conditions on the progressive ratio schedule. Furthermore, if progressive satiation were a principal determiner of progressive ratio performance, one could expect increases in the concentration or volume of the milk reward to diminish the number of responses in the final ratio run. This was clearly not the case.

A comparison of the upper and lower halves of Fig. 1 illustrates the effects of two aspects of amount of reward. The upper half represents the effects of variation in the concentration of the reward while the lower half depicts the effects of differential volumes of reward as a parameter. Investigations are currently in progress in this laboratory in which the volume of the reward is being varied over a wide range in order to gather further data on the relationship between reward volume and reward "attractiveness." In addition, the size of the increment by which each ratio run increases is being systematically varied.

Since performance on the progressive ratio schedule seems to correlate well with variations in reward and deprivation parameters, it may well find application as a means of evaluating the relative rewarding properties of intracranial self-stimulation.

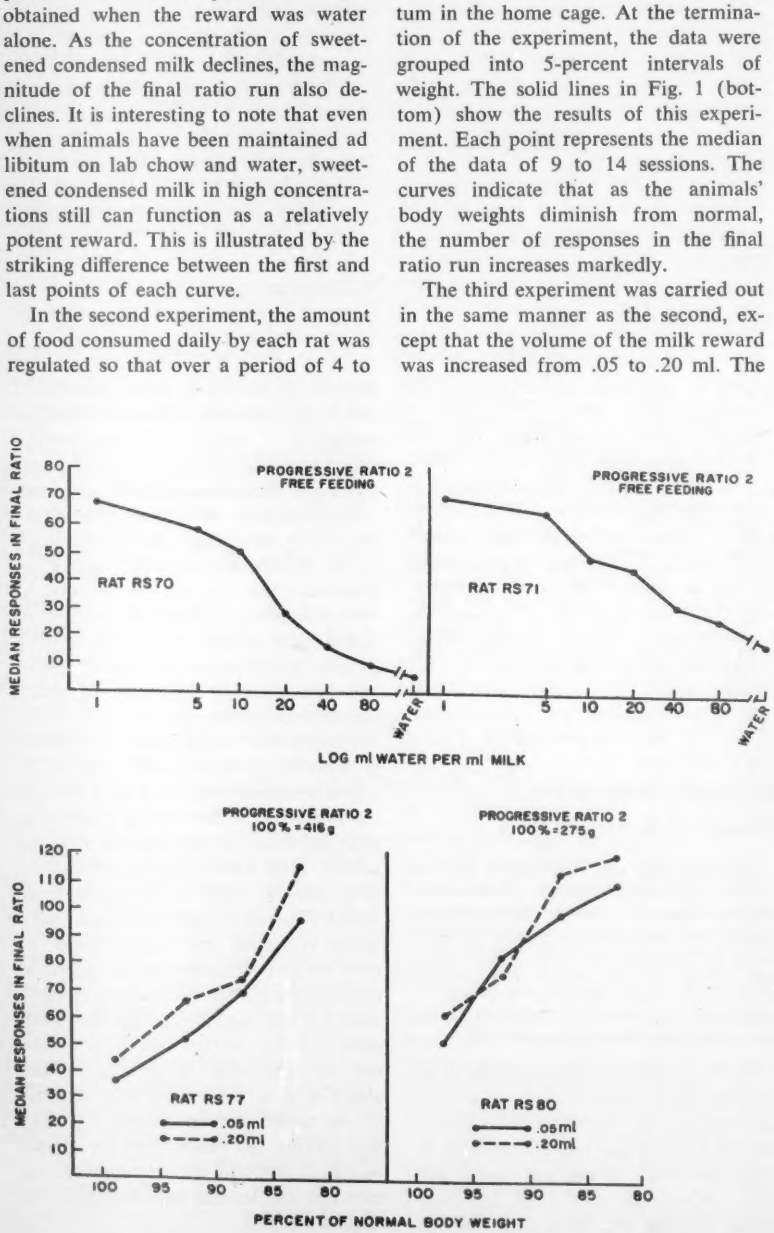

Fig. 1. The number of responses in the largest completed ratio run is plotted as a function of several levels of reward and deprivation variables. (Top) The effect of decreasing the concentration of the reward. (Bottom) Effect of increasing food deprivation and the volume of the reward.

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9 June 1961

Desynchronized Electroencephalogram in the Deeply Sleeping Cat

Abstract. Electroencephalographic patterns of the different stages of sleep in the cat are shown, with special reference to a desynchronized deep sleep. This sleep stage is characterized by an increase in reticular stimulation arousal threshold and by the reappearance of 5 to 6 spikes per second on the electroencephalogram immediately after threshold behavioral arousal.

After Dement and Kleitman (*1*) first described a low-voltage, fast electroencephalographic sleep cycle in humans, the same type of activity was described in cats by Dement (*2*) and later by Jouvet *et al.* (*3*). We have duplicated this desynchronized sleep electroencephalogram in five of our cats that have been implanted with bipolar electrodes in various deep and surface structures of the brain. These animals have been trained to go to sleep in a sound-proofed room. Behavioral and electroencephalographic arousal thresholds in response to stimulation of the reticular formation are then recorded.

The cats exhibited the normal behavioral and electroencephalographic patterns associated with going to sleep, and after 60 or more minutes of complete isolation they drifted into a very high frequency (40 to 50 per second), low amplitude, desynchronized activity (Fig. 1*B*). As described by Jouvet *et al.* (*3*), the animals were completely relaxed and deeply asleep. Especially noticeable are the occasional convulsive limb twitches. One of the cats slept with the eyes partially open during this phase. She showed marked nystagmic movements of the eyeball under relaxed nictitating membranes.

Although Dement (*4*) states that he cannot detect changes in arousal threshold between the fast- or slow-wave sleep stages, we have found increases in the reticular formation behavioral arousal thresholds of from 1 to 2.5 volts in all of our cats (Fig. 1). This finding confirms Jouvet's report (*3*) of increased auditory and reticular arousal thresholds during this sleep period.

One aspect of this desynchronized sleep stage not yet reported is shown in Fig. 1*C*. Recticular stimulation that was just enough to produce a minimal behavioral arousal (eyes open, head moves briefly) produced an almost immediate 5 to 6 per second activity which drifted into a slow-wave sleep activity and then once again into the 40 to 50 per second deep-sleep pattern.

Since the above-mentioned arousal threshold is higher than that of the slow-wave sleep, and since even minimal behavioral arousal from slow-wave sleep produces a considerable length of aroused electroencephalographic activity (instead of the 5 to 6 per second activity we find in the arousal from fast-wave sleep), we feel that the desynchronized sleep pattern is definitely indicative of a deeper sleep stage than the conventionally described deep sleep during a synchronized electroencephalogram.

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Squibb Institute for Medical Research, New Brunswick, New Jersey

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2 June 1961

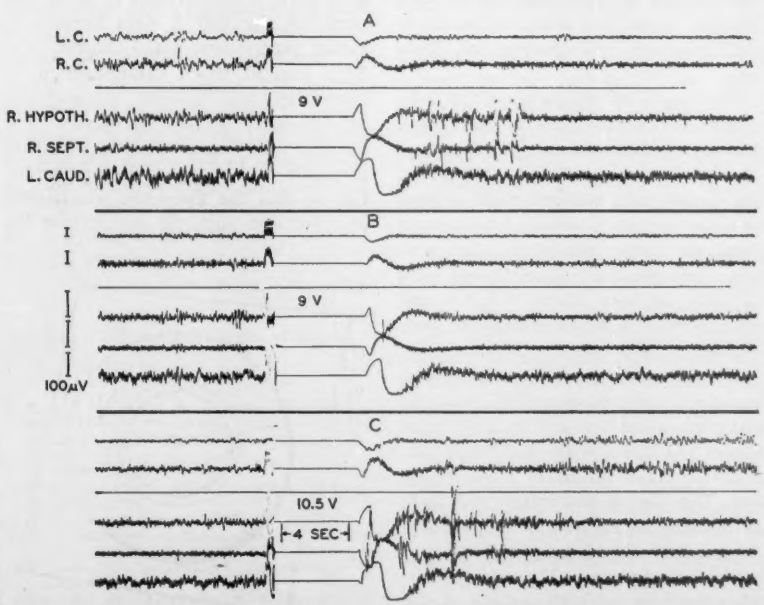

Fig. 1. *A*, Behavioral and electroencephalographic arousal with 9.0 volts at synchronized sleep stage. Notice movement artifact after stimulation. *B*, No behavioral arousal with 9.0 volts at desynchronized sleep stage. *C*, Behavioral and electroencephalographic arousal with 10.5 volts at desynchronized sleep stage. Recording pens off during stimulation (5 sec, 100 cy/sec, 0.1 msec).

An Unfortunate Event

We have had our attention drawn to several discrepancies in a paper by Pande *et al.* (*1*) which was recently published in *Science* under the title "Toxoplasma from the eggs of the domestic fowl (*Gallus gallus*)."

The discrepancies concern the figures used to illustrate the paper. Figures 1 and 2 represent the same object, although they are described as picturing different forms of *Toxoplasma gondii* from different sources. A point-by-point comparison of the two figures shows beyond doubt that Fig. 1 is merely an enlargement of a part of Fig. 2 and that it is tilted at a slight angle.

The relevant part of the caption for Fig. 1 reads: "Cyst stages of *Toxoplasma gondii* in the impression smear of chorioallantoic membrane"; that for Fig. 2 reads: "Pseudocyst of *Toxoplasma* in the ovary of white Leghorn hen." In addition, the "ghosts" of red blood cells in the background of these figures, professedly of avian origin, appear nonnucleated, and therefore mammalian.

Figure 3 in the same paper, which purports to be an original photograph, is a slightly enlarged copy of Fig. 1 in an earlier paper by Frenkel (*2*), which was entitled, "Pathogenesis of toxoplasmosis and of infections with organisms resembling *Toxoplasma*." Frenkel's caption to his Fig. 1 reads: "*Toxoplasma*, fresh preparation from peritoneal exudate of mouse, showing organism

free and within macrophage. Red blood corpuscles, some of which are crenated, provide a comparison for size. Phase-contrast microscope. Times 1000." The caption for Fig. 3 in the paper by Pande *et al.* reads: "Extracellular forms in the impression smear of peritoneal exudate of mice. Note the crenated erythrocytes (phase-contrast × 1500). [May-Grunwald-Giemsa]."

We apologize to our readers for this unfortunate event, thus following the precedent set by the Editorial Board of the *Journal of Infectious Diseases* (*3*) in a similar case in which at least five of the six figures used to document an article (*4*) "were taken from the previously published work of other authors."

GRAHAM DUSHANE, *Chairman*
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EDWIN M. LERNER
PHILIP M. MORSE
H. BURR STEINBACH
WILLIAM L. STRAUS, JR.
EDWARD L. TATUM
Editorial Board, Science,
Washington, D.C.

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Phagocytized Platelets: A Source of Lipids in Human Thrombi and Atherosclerotic Plaques

Abstract. Phagocytosis of lipid-rich platelets by monocytes and the transformation of such cells into lipophages containing fat was observed in human thrombi. The lipophages are similar to lipophages in atherosclerotic plaques. This observation supports the idea that some atherosclerotic plaques are organized mural thrombi.

Recently, in this laboratory, the conversion of autologous pulmonary arterial thromboemboli to typical fibrofatty atherosclerotic plaques containing foam cells (lipophages) was observed in the rabbit (*1*). The lipophages were derived from monocytes that had phagocytosed and digested lipid-rich platelets within the thromboemboli. After this experiment with the rabbit, a study was made of human in vivo and in vitro thrombi to determine whether or not phagocytosis of platelets could be found.

Thrombi made in vitro (*2*) from human plasma were incubated at 34° to 37°C for 1 to 6 days. The thrombi were composed of clumps and columns of aggregated platelets surrounded by monocytes and by granulocytes, and bound together by strands of fibrin. Phagocytosis of platelets by monocytes within the thrombi occurred on the second day of incubation (Fig. 1*a*), and the transformation of such cells to lipophages containing fat occurred by the fifth day (Fig. 1*b*). The cytoplasm of the phagocytic monocytes was filled with numerous platelets, and the nucleus was displaced to an eccentric position. Swollen platelets could be distinguished in the monocytes in the early stages of fatty change. However, by the sixth day many of the phagocytized platelets had become lysed and were replaced by fatty vacuoles characteristic of foam cells.

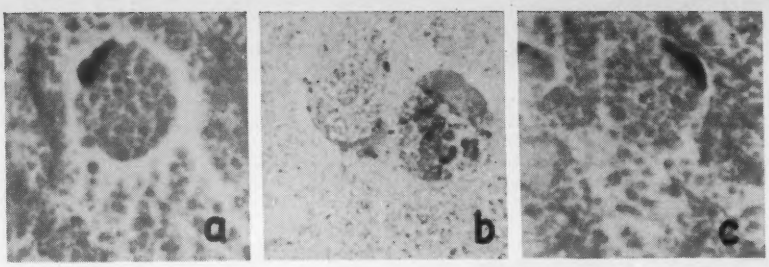

Fig. 1. Phagocytized platelets (× 400) in monocytes of in vitro thrombi (*a*, *b*) and an in vivo thrombus (*c*). Note the similarity of the phagocytic monocytes in *a* and *c* (hematoxylin and eosin stains). Two monocytes in *b* contain platelets. The platelets in the cell on the right are undergoing fatty change (Fettrot fat stain; fat is black in photograph).

The degree of phagocytosis and fatty change varied from cell to cell. Some monocytes that had not phagocytosed platelets accumulated fine droplets of fat. These cells retained their normal size and could be easily distinguished from the large monocytes that contained phagocytized platelets and fatty vacuoles. In some thrombi a few unphagocytized platelets underwent fatty change.

In each experiment 10 ml of venous blood was collected in a plastic tube (*3*), and plasma was obtained by centrifugation of the blood in the collection tube at 650 to 700 rev/min for 5 to 10 minutes. The plasma was transferred in 1-ml portions to each of three polyvinyl chloride tubes 20 cm long by 0.140 inch in internal diameter. The ends of the tubes were joined with outside plastic collars to form a circle. Then the tubes, filled approximately half with plasma and half with air, were rotated at 17 rev/min on inclined turntables (Fig. 2) until thrombi formed (15 to 20 min).

The contents of one circular tube—the thrombus in its own plasma—were incubated in each experiment. Before incubation, the tube was further sealed with paraffin at the junction, and the air in the tube was replaced with a mixture of 95 percent oxygen and 5 percent carbon dioxide by means of inlet and outlet needles. The remaining two tubes were stored at 5°C, and the plasma was used for replacement of the autologous media in the incubated tube on the second and fourth day of incubation. After each plasma exchange, the gas mixture was also replaced.

The thrombus was incubated at 34°C for 2 days and at 37°C for the next 1 to 4 days. A temperature of 34°C was used for the first 2 days because in earlier experiments initial incubation at 37°C caused much multiplication of monocytes and minimal phagocytosis of platelets by the monocytes. The circular tube was rotated on a vertical turntable at 1 rev/min during incubation so that the thrombus was carried alternately through the plasma and the

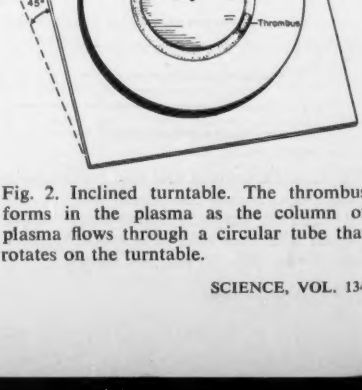

Fig. 2. Inclined turntable. The thrombus forms in the plasma as the column of plasma flows through a circular tube that rotates on the turntable.

gas. In order to prevent the thrombus from floating in the plasma, the lumen of the tube was constricted at one point by an outside metal clip. Aseptic sterile technique was used throughout the experiment.

A total of 165 experiments were performed on the plasma of blood obtained from adult patients of the outpatient clinic of the Eugene Talmadge Memorial Hospital of the Medical College of Georgia. Samples were taken from most of the patients before and after an operation or delivery. Several variations in the experiment were tried initially. Sixty-seven experiments were done as described above, and lipophages were identified in 28 of 45 thrombi that were stained for fat. All thrombi were examined histologically.

Human in vivo thrombi in the early stages of degeneration and organization also contained lipophages similar to those in atherosclerotic plaques. Phagocytosis of platelets was observed in 58 of 134 venous and arterial thrombi that were obtained at autopsy and varied in estimated age from a few hours to several weeks (Fig. 1*c*). Phagocytosis was most pronounced in the first 2 weeks. In some thrombi transitional cells containing both fat and platelets were observed.

The concept that some atherosclerotic plaques are mural thrombi altered by degeneration and organization is supported by many investigators who have traced the conversion of fibrin to fibrous intimal plaques in both human and experimental thrombi (*4*). Since fibrin is a fibrous protein that contains no lipid (*5*), it does not account for fat in plaques. However, platelets are rich in lipids, including cholesterol (*6*), and are a principal constituent of arterial thrombi (*7*).

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6. B. Maupin, *Les Plaquettes Sanguines de l'Homme* (Masson, Paris, 1954), p. 102. Lipids including neutral fats, phospholipids, and cholesterol constitute 19 percent, dry weight, of platelets; cholesterol accounts for 3.9 percent; proteins, including lipoproteins, total 57 percent.
7. This work was supported in part by a grant (H-3973) from the U.S. Public Health Service. We wish to thank Marion Hutson, Teresa Klett, and Mrs. David Fulghum for their technical assistance.

12 June 1961

Continuous Compensatory Tracking by a Cebus Monkey

Abstract. A cebus monkey was trained to hold a continuously moving voltmeter needle on-target for 60 seconds to obtain a food-pellet reinforcement. The task confronting the animal was relatively complex in that the high-frequency error voltage fed to the voltmeter needle was nulled by the animal by means of a joystick physically separated from the stimulus display.

The investigation reported here was designed to determine whether a cebus monkey could be trained to perform continuous compensatory tracking in one dimension with (i) food reward as a positive reinforcement, (ii) a relatively complex tracking task, and (iii) a control stick physically separated from the stimulus display. Such a response would be invaluable for providing precision monitoring of animal behavior in studies where conditions such as drug states, space flights, and so forth, would preclude the use of human subjects.

The apparatus as seen by the monkey is shown in Fig. 1. A potentiometer attached to the bottom of the self-centering control stick (*A*) provided a voltage change proportional to stick position. A ½-inch target zone (*D*), in the center of the milliammeter (*B*), was illuminated by a red 6-volt bulb any time the needle (*C*) entered the zone.

A cam-generated forcing function produced an irregular needle deflection of ±1 inch, and had a frequency of approximately 10 cy/min. The potentiometer attached to the stick enabled the animal to null the cam-generated error voltage and receive a reinforcement (food pellet). The error voltage drove a pen on a multichannel recorder, and, when reduced by the monkey to a sufficiently low magnitude, started a synchronous timer and actuated the on-target light in the center of the meter face. When the animal held the needle on target for the length of time set into the synchronous timer, a 0.67-g pellet of whole-diet food was delivered to the food cup by a mechanized food dispenser (see *E* in Fig. 1).

To prevent the monkey from obtaining free food pellets during early training stages as the needle passed through the target zone, the needle was set to fluctuate about a point 2 inches to the right or left of the target zone (see trace *A* in Fig. 2).

Although the animal was unrestrained and free to move the stick at any time, the food delivery equipment was energized only 1 hour in the morning, 1 hour at noon, and 1 hour at night. Since the monkey was not fed at any other time, it was under 16 hours of food deprivation in the morning, and under 4 hours of deprivation before each of the other two sessions. At feeding times (which were controlled automatically by a 24-hour timer), the room lights were shut off, the small light behind the face of the meter was turned on, and the multichannel graphic recorder was started. If the stage of practice required it, the forcing-function cam was also started at this time. After 1 hour, the apparatus was automatically turned off and the room lights were automatically turned on.

With the exclusion of delays due to apparatus failures and experimenter error, it is estimated that the training lasted approximately 30 days, or 90 experimental hours. In the first phase of training the monkey was taught to compensate for a discrete deflection of the display needle. Initially, any deflection by the control stick that caused the needle to cross the target zone was rewarded no matter how small an amount of time it remained in the target zone. The delivery of the food pellet was accompanied by an audible click of a relay and the illumination of the red

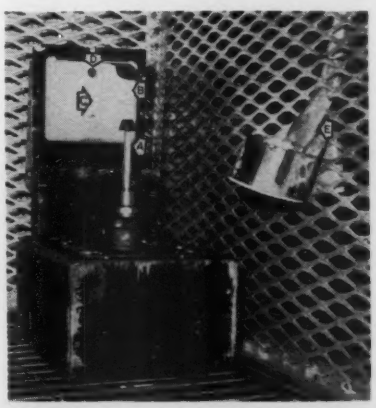

Fig. 1. Apparatus as seen by the monkey (*A*, control stick; *B*, meter; *C*, needle; *D*, target zone; *E*, food dispenser).

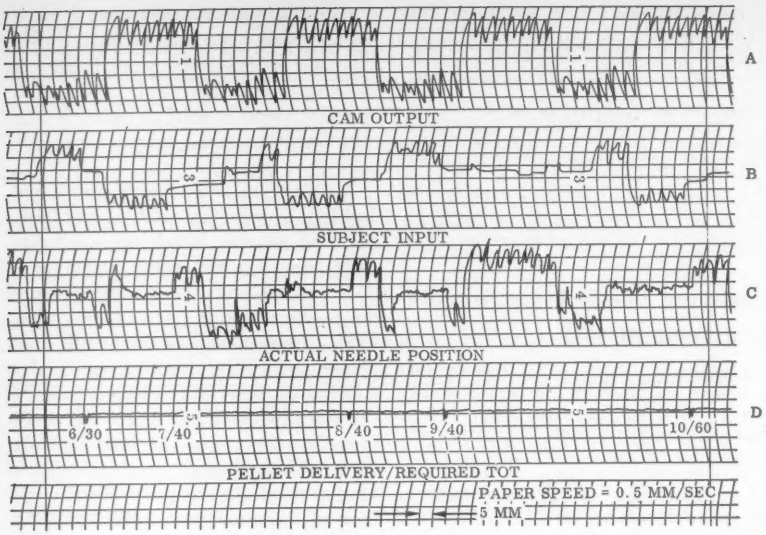

Fig. 2. Graphic record of a 7-min tracking run obtained at termination of monkey's training.

light behind the target aperture. The necessary time-on-target was gradually increased until the monkey had learned to hold a corrective stick deflection for as long as 10 sec. A 10-sec maximum was used since it was felt that forcing the animal to maintain a discrete stick deflection for a longer period of time would be a difficult response to extinguish when the needle was eventually switched to continuous motion.

The last phase of training involved the transition from discrete to continuous tracking, and the development of the continuous tracking response to a high level of proficiency. The transition was accomplished by turning on the error generator and reducing the required time-on-target to an interval still large enough (0.5 sec) to prevent the monkey from obtaining "free" pellets when the needle passed through the target zone on its way to the other side. Although the needle now moved continuously, the animal continued making more or less appropriate control stick responses, indicating that it had mastered the association between the centering of the needle (as a result of its manipulation of the control stick) and the food reward. During the initial stages of the transition from discrete to continuous tracking, the monkey was awarded a pellet by the experimenter if the needle remained in the target zone for as short a period as 0.25 sec (if the time-on-target was not caused by the periodic cam-induced movement of the needle through the target zone). When the monkey was able to obtain 25 to 30 food pellets per session, the required time-on-target was increased by a small amount until the animal was able to track continuously up to 60 sec at a time without letting the needle get off-target.

A graphic record of a 7-min tracking run obtained at the termination of the training is shown in Fig. 2. The upper trace (*A*) portrays the cam-induced forcing function which served as the input to the display needle. Trace *B* is a record of the monkey's input; a straight line down the middle of the recording space indicates no input at all. Trace *C* is a combination of traces and represents the actual needle position as a function of both the cam input and the monkey's input. A straight line down the middle of the recording space on trace *C* would indicate that the monkey had been compensating perfectly for fluctuations induced by the cam. Trace *D* depicts when the subject performs well enough to obtain a food reward; the numbers 30, 40, and 60 to the right of the slash indicate the number of seconds on-target necessary for the pellet to be delivered. The numbers to the left of the slash indicate cumulatively the number of pellets the monkey had obtained at successive points during the 7-min tracking run.

The precision of the monkey's response is indicated by the relatively small fluctuations in the needle during the 60-sec tracking run in trace *C* (Fig. 2). The tracking performance exhibited on this and other runs is quite precise, since the full width of the recording space corresponds roughly to 4½ inches on the meter face. Further, even during the rapid cross-over period to the opposite side of the meter, the needle was kept within the error tolerance zone.

From these results, it appears possible to train subhuman primates to perform continuous compensatory tracking tasks that are not unlike those faced by human trackers. This finding suggests the possibility of using animal subjects as substitutes for humans in many more types of behavioral research situations.

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Note

1. This research was made possible by the basic research program of Electric Boat Division, General Dynamics Corporation. I wish to acknowledge the assistance of Dr. Raymond C. Sidorsky for critically reading the manuscript and to thank Robert S. Johnson for his general assistance throughout the course of the study.

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17 May 1961

Association Affairs

Election of AAAS Officers

The AAAS Committee on Nominations and Elections, in meeting on 11 July, selected the following lists of nominees for AAAS offices. All nominees have agreed to serve if elected.

President-elect (one to be elected)
George R. Harrison
Alan T. Waterman

Members of the Board of Directors (two to be elected)
Allan D. Bass
Henry Eyring
Mina S. Rees
William W. Rubey

The Board members whose terms expire at the end of 1961 are Henry Eyring, who was elected last year to serve the final year of an uncompleted term, and William W. Rubey, who will complete a full 4-year term.

Members of the Committee on Council Affairs (three to be elected)
Stanley S. Ballard
Stanley A. Cain
F. Raymond Fosberg
Robert C. Miller
Kenneth C. Spengler
Frank Bradshaw Wood

The Committee on Council Affairs was established by Council at the 1960 meeting, and nine members were elected at that time. The three who were elected for 1-year terms were Stanley A. Cain, Kenneth C. Spengler, and Frank Bradshaw Wood.

Election procedures adopted by the Council provide that the names of additional nominees may be included on the ballot on petition signed by no fewer than 30 members of the Council and submitted to the Executive Officer no later than 1 November.

Election ballots will be mailed to Council members shortly after 1 November. Results of the election will be announced at the Council meeting on 27 December in Denver.

Biographical information concerning the nominees follows.

George R. Harrison

George R. Harrison, 63 (physics), instructor, Stanford University, 1919–23; National Research Council Fellow, Harvard University, 1923–25; assistant professor, Stanford, 1925–27; associate professor, 1927–30; professor, Massachusetts Institute of Technology, 1930–, director, Research Laboratory of Experimental Physics, 1930–42, dean, School of Science, 1942–; civilian with National Defense Research Committee, Office of Scientific Research and Development, Office of Field Service, Southwest Pacific Area, 1940–46; president, Optical Society of America, 1946–48; chairman, American Institute of Physics, 1947–54; awarded Rumford Medal, 1939; Medal of Freedom, 1946; Presidential Medal for Merit, 1948; Ives Medal, 1949; Cresson Medal, Franklin Institute, 1953; Spectroscopy Awards, 1955, 1957.

AAAS activities: member, Board of Directors, 1956–59; member, Committee on Publications, 1957–; member, Committee on Nominations and Elections, 1958, chairman, 1959.

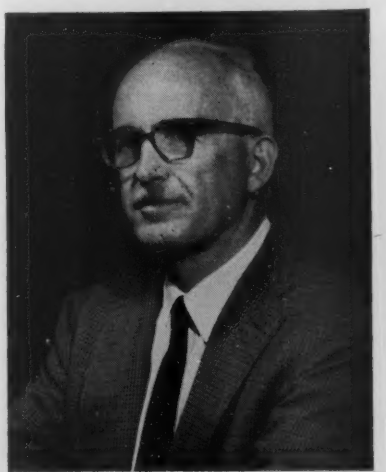
Alan T. Waterman

Alan T. Waterman, 69 (physics), instructor, University of Cincinnati, 1916–17; Yale University, 1919–23, assistant professor, 1923–30, associate professor, 1931–48; vice chairman, division D, National Defense Research Committee, 1942–43; deputy chief, office field service, Office of Scientific Research and Development, 1943–45, chief, 1945–46; chief scientist, planning division, Office of Research and Inventions, 1946; deputy chief and chief scientist, Office of Naval Research, 1947–51; director, National Science Foundation, 1951–; member, Editorial Board, *American Journal of Science*, 1934–42; awarded Presidential Medal for Merit, 1948; first annual Captain Robert Dexter Conrad Award by the Office of Naval Research, 1957; Public Welfare Medal of the National Academy of Sciences, 1960; Procter Prize, 1960.

AAAS activities: vice president and chairman, Section B (Physics) 1955; member, Board of Directors, 1957–; member, Committee of Judges, AAAS–Westinghouse Science Writing Awards, 1959–60; member, Executive Committee, 1960–61.

Allan D. Bass

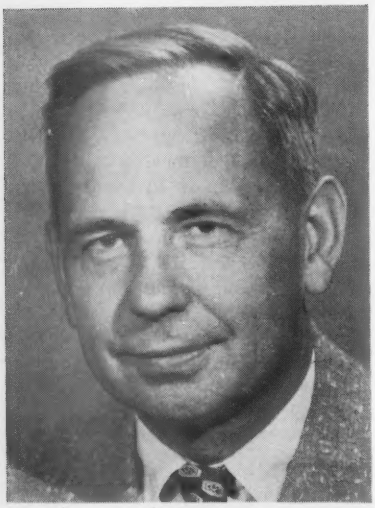
Allan D. Bass, 51 (medical science, pharmacology), research assistant, Vanderbilt Medical School, 1937–39; intern in medicine, Vanderbilt Hos-



George R. Harrison

Alan T. Waterman

Allan D. Bass



Henry Eyring

pital, 1939–40, assistant resident, 1940–41; American College of Physicians Fellow, Yale Medical School, 1941–42, instructor, department of pharmacology, 1942–43; instructor, department of medicine, Vanderbilt, 1943–44; U.S. Army Medical Corps, Philippine Islands, 1944–45; professor and chairman, department of pharmacology, State University of New York, Syracuse, 1945–52; professor and chairman, department of pharmacology, Vanderbilt Medical School, 1953–; treasurer, American Society for Pharmacology and Experimental Therapeutics, 1958–60; chairman, Educational Affairs Committee, 1955–60; chairman, Pharmacology Test Committee, National Board of Medical Examiners, 1955–60; member, Pharmacology and Experimental Therapeutics Study Section, National Institutes of Health, 1960–; member, Advisory Panel for Study on Manpower Needs in the Basic Health Sciences, Federation of American Societies for Experimental Biology, 1961–; chairman, 1958–59, and member, 1960–, Health Section, Nashville Council of Community Agencies.

AAAS activities: editor of two AAAS symposium volumes; secretary, Section N (Medical Sciences), 1952–60; member, Committee on Council Activities and Organization, 1960; member, Committee on Council Affairs, 1961–.

Henry Eyring

Henry Eyring, 60 (chemistry), instructor, University of Arizona, 1924–25; teaching fellow, University of California, 1925–27; instructor, University of Wisconsin, 1927–28, research associate, 1928–29; lecturer, University of California, 1930–31; research associate, Princeton University, 1931–36, associate professor, 1936–38, professor, 1938–46; dean of the graduate school, University of Utah, 1946–; director of fundamental research, Textile Foundation, Textile Research Institute, 1944–46; awarded AAAS Newcomb Cleveland Prize, 1932; Research Corporation Award, 1949; second Bingham Medal from Society of Rheology, 1949; William H. Nichols Medal, 1951; Salt Lake City American Chemical Society Award, 1961.

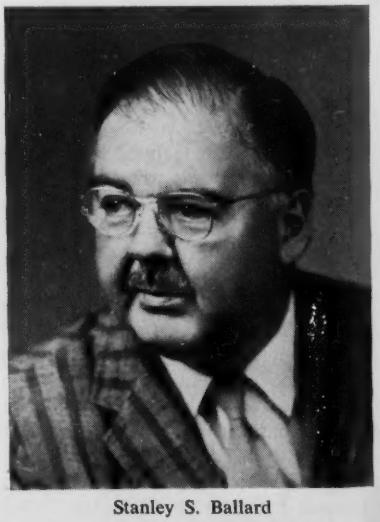
AAAS activities: vice president and chairman, Section C (Chemistry), 1945–46; president, Pacific Division, 1959; member, Board of Directors, 1961.

Mina S. Rees

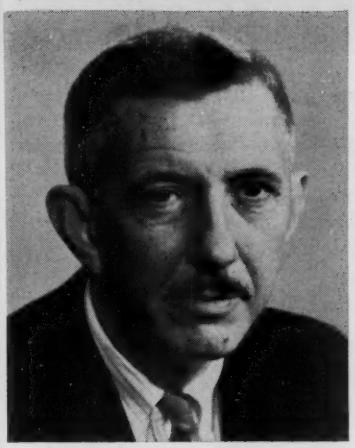
Mina S. Rees, 59 (mathematics), instructor, Hunter College, 1926–32, assistant professor, 1932–40, associate professor, 1940–50, professor and dean of faculty, 1953–61; dean of graduate studies, City University of New York, 1961–; technical aide, administrative assistant to chief of applied mathematics panel, Office of Scientific Research and Development, 1943–46; head, mathematics branch, Office of Naval Research, 1946–49, director, mathematical sciences division, 1949–52, deputy science director, 1952–53; member, Mathematics Policy Committee, 1952–53; member, mathematics division, National Research Council, 1953–56, executive committee, 1954–

Mina S. Rees. [Bradford Bachrach]

William W. Rubey. [Fabian Bachrach]

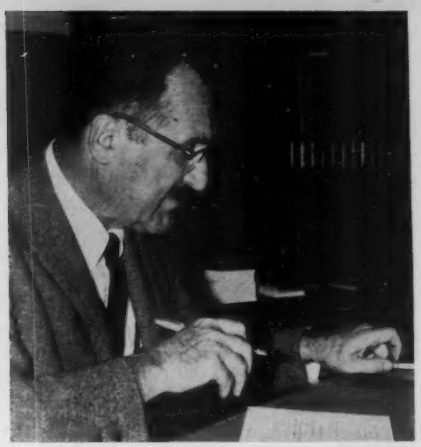


Stanley S. Ballard



Stanley A. Cain

F. Raymond Fosberg



Robert C. Miller. [M. Graham Netting]

56; member, general sciences advisory panel, Department of Defense, 1957–61; member, advisory commission for mathematics, National Bureau of Standards, 1954–60, chairman, 1954–57; member, advisory panel for mathematical sciences, National Science Foundation, 1955–58; member, Council, New York Academy of Sciences, 1956–59; member, Conference Board of the Mathematical Sciences, 1960–; awarded President's Certificate of Merit, 1948.

AAAS activities: vice president and chairman, Section A (Mathematics), 1954; member, Board of Directors, 1958–60.

William W. Rubey

William W. Rubey, 62 (geology), instructor, Yale University, 1922–24; geologic aide to principal geologist, U.S. Geological Survey, 1920–44, geologist in charge, division of areal geology and basic sciences, 1944–47, research geologist, 1947–60; professor of geology and geophysics, University of California (Los Angeles), 1960–; chairman, division of geology and geography, National Research Council, 1943–46, general chairman, 1951–54; president, Geological Society of America, 1949–50; vice president, American Geological Institute, 1950–51 and 1958–59; member, National Science Board, 1960–; member, Board of Directors, Geochemical Society, 1955–57; councillor, American Philosophical Society, 1956–59; visiting professor of geology, Institute of Geophysics, University of California (Los Angeles), 1954, California Institute of Technology, 1955, Johns Hopkins University, 1956.

AAAS activities: member, Board of Directors, 1957–61; member, Committee on Section E, 1939–42; member, Newcomb Cleveland Prize Committee, 1951, 1958–60; representative on Science Service Board of Directors, 1956–; member, Executive Committee, 1958–59.

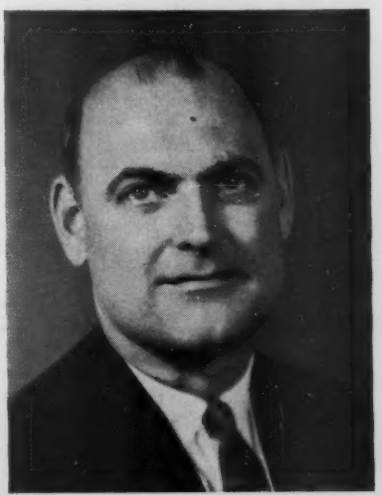
Stanley S. Ballard

Stanley S. Ballard, 52 (physics), instructor, University of Hawaii, 1935–37, assistant professor, 1937–41; lieutenant, lieutenant commander, and commander, U.S. Naval Reserve, on active duty in U.S. Navy Bureau of Ordnance, 1941–46; professor and department chairman, Tufts College, 1946–53; physicist, Rand Corporation, 1953–54; research physicist, Scripps Institution of Oceanography, 1954–58; professor and department head, University of Florida, 1958–; executive secretary, Armed Forces–National Research Council Committee on Vision, 1956–59; officer and/or director, Optical Society of America, 1947–59; chairman, Western Spectroscopy Association, 1956–57; president, Sigma Pi Sigma, 1959–; vice president, International Commission of Optics, 1948–56, president, 1956–59.

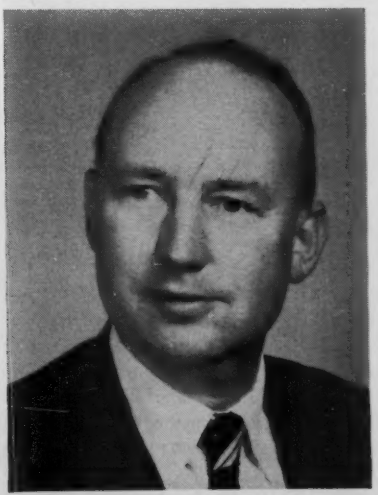
AAAS activities: secretary, Section B (Physics), 1960–.

Stanley A. Cain

Stanley A. Cain, 59 (botany), instructor, Butler University, 1925–27, assistant professor, 1928–30, associate professor, 1930–31; assistant professor, Indiana University, 1931–33, research associate, Waterman Institute for Re-



Kenneth C. Spengler



Frank Bradshaw Wood

search, 1933–35; assistant professor, University of Tennessee, 1935–37, associate professor, 1937–42, professor, 1942–46; botanist, Cranbrook Institute of Science, 1946–50; Charles Lathrop Pack professor of conservation and chairman, conservation department, University of Michigan, 1950–61; chief, Science Section, American Army University, Biarritz, France, 1945–46; expert in ecology, Technical Assistance Mission to Brazil, UNESCO, 1955–56; member, Advisory Board, Conservation Foundation, 1954–; treasurer, Ecological Society of America, 1938–40, vice president, 1953, president, 1958; secretary, Society for the Study of Evolution, 1946–48, vice president, 1954; awarded Certificate of Merit, Golden Jubilee, Botanical Society of America, 1956; Distinguished Faculty Award, University of Michigan, 1959.

AAAS activities: secretary, Section G (Botanical Sciences), 1948–53, vice president and chairman, 1954; member, AAAS Newcomb Cleveland Prize Committee, 1958; member, Committee on AAAS Meetings, 1960–; member, Committee on Council Affairs, 1961.

F. Raymond Fosberg

F. Raymond Fosberg, 53 (botany, ecology), assistant botanist, Los Angeles Museum, 1930–32; assistant in botany, University of Hawaii, 1932–37; Mangarevan Expedition, Bishop Museum, 1934; Morris Fellow, University of Pennsylvania, 1937–39; assistant botanist, U.S. Department of Agriculture, 1939–42, botanist, 1945–46; senior botanist, U.S. Foreign Economic Administration, 1942–45; botanist, Micronesian Economic Survey, U.S. Commercial Company, 1946–47; John Simon Guggenheim Fellow, 1947; visiting professor, University of Hawaii, 1948; professorial lecturer, George Washington University, 1948–49; research associate, Catholic University of America, 1949–50; botanist, U.S. Geological Survey, 1951–; member, First International Symposium on Plant Taxonomy and Nomenclature, Utrecht, 1948; Pacific Science Board, National Academy of Sciences–National Research Council, 1957–; UNESCO Advisory Committee for Humid Tropics Research, 1956–; National Research Council, 1959–; chairman, Standing Committee for Pacific Botany, Pacific Science Association, 1954–; chairman, UNESCO Visiting Committee for Tropical Herbaria, 1960–; founding member, World Academy of Art and Science, 1961; awarded Pierre Fermat Medal, 1960.

AAAS activities: Council member, 1959–.

Robert C. Miller

Robert C. Miller, 62 (zoology), research associate, University of California, 1923–24, assistant professor, University of Washington, 1924–30, associate professor, 1930–36, professor, 1936–38; visiting professor, Lingnan University, China, 1929–31; director, California Academy of Sciences, 1938–; president, Cooper Ornithological Society, 1943–45.

AAAS activities: member, Committee on Agenda and Resolutions, 1959–60; secretary-treasurer, Pacific Division, 1944–; president, Academy Conference, 1961.

Kenneth C. Spengler

Kenneth C. Spengler, 45 (meteorology), statistician, Pennsylvania Department of Labor and Industry, 1937–38; accountant, Pennsylvania Public Utility Commission, 1938–40; secretary, Weather Research Center, U.S. Air Force, 1941; chief, Climatology and Verification Sections, Air Weather Service, 1942–43; chief, Weather Central, Headquarters, U.S. Air Force, 1944–45; executive secretary, American Meteorological Society, 1946–; member, Department of Commerce Advisory Committee on Weather Services, 1953; member, National Advisory Committee on Weather Control, 1953–58.

AAAS activities: member, Committee on Council Agenda and Resolutions, 1958–60; member, Committee on Council Affairs, 1961.

Frank Bradshaw Wood

Frank Bradshaw Wood, 45 (astronomy), U.S. Naval Reserve, active duty, 1941–45; research associate, Princeton University, 1946; National Research Fellow, Steward Observatory, University of Arizona, and Lick Observatory, University of California, 1946–47; assistant professor of astronomy, University of Arizona, 1947–50; associate professor and executive director, Flower and Cook Observatory, University of Pennsylvania, 1950–54, professor and director, 1954–, chairman of department, 1954–57, 1958–, Flower Professor of Astronomy, 1958–; Fulbright Fellow, Mount Stromlo Observatory, Australian National University, 1957–58; member, International Astronomical Union, 1948–; council member, American Astronomical Society, 1958–61.

AAAS activities: secretary, Section D (Astronomy), 1958–; member Committee on Meeting Sites, 1958–59; member Newcomb Cleveland Prize Committee, 1960; member, Committee on Council Affairs, 1961; editor, AAAS symposium volume, *Astronomical Photoelectric Photometry*, 1953.

Forthcoming Events

October

23–28. Congress of Chemical Engineering, 1st, San Juan, P.R. (R. Munoz, Apartado 47, Estación de Río Piedras, San Juan)

24–25. Shallow Water Research Conf., Gulf Coast, 1st natl., Tallahassee, Fla. (D. S. Gorsline, Oceanographic Inst., Florida State Univ., Tallahassee)

24–26. Aerospace Nuclear Propulsion, intern. symp., Las Vegas, Nev. (P. M. Uthe, Lawrence Radiation Laboratory, Univ. of California, Box 808, Livermore)

24–27. American Dietetic Assoc., 44th annual, St. Louis, Mo. (Mrs. T. Pollen, ADA, 620 N. Michigan Ave., Chicago 11, Ill.)

26–27. American Soc. of Tool and Manufacturing Engineers, Toronto, Canada. (A. Cervenka, Vanderbilt Blvd., Oakdale, L.I., N.Y.)

26–27. Instrumentation Facilities for Biomedical Research, symp., Omaha, Neb. (H. G. Beenken, Univ. of Nebraska College of Medicine, 42 and Dewey Ave., Omaha)

26–27. New Mexico Acad. of Science, Albuquerque. (K. G. Melgaard, P.O. Box 546, Mesilla Park, N.M.)

26–28. Professional Group on Electron Devices, annual meeting, Washington, D.C. (I. M. Ross, Technical Program Chairman, Room 2A-329, Bell Telephone Laboratories, Murray Hill, N.J.)

26–30. American Soc. for Aesthetics, Detroit, Mich. (J. R. Johnson, Cleveland Museum of Art, Cleveland 6, Ohio)

27–28. Shallow Water Research Conf., Pacific Coast, 1st natl., Los Angeles, Calif. (D. S. Gorsline, Oceanographic Inst., Florida State Univ., Tallahassee)

27–29. Association of Clinical Scientists, annual, Washington, D.C. (R. P. MacFate, Secretary, ACS, 323 Northwood Rd., Riverside, Ill.)

28. American Mathematical Soc., 583rd meeting, Cambridge, Mass. (E. Pitcher, Lehigh Univ., Bethlehem, Pa.)

29–31. Photoelasticity, intern. symp., Chicago, Ill. (P. D. Flynn, Illinois Inst. of Technology, Chicago 16)

29–1. Marine Biology, intern. conf. (by invitation only), Princeton, N.J. (Mrs. E. Purcell, Interdisciplinary Conference Program, Rockefeller Center, Time & Life Bldg., New York 20)

30–1. American Oil Chemists Soc., Chicago, Ill. (W. O. Lundberg, Hormel Inst., Univ. of Minnesota, 801 16th Ave., NE, Austin)

30–1. Society of Rheology, annual,

Madison, Wis. (J. D. Ferry, Univ. of Wisconsin, Madison)

31–2. Interscience Conf. on Antimicrobial Agents and Chemotherapy, 1st, American Soc. for Microbiology, New York, N.Y. (ASM, 19875 Mack Ave., Detroit 36, Mich.)

November

1. Rheumatic Fever, symp., New Haven, Conn. (E. A. Sillman, Connecticut Heart Assoc., 65 Wethersfield Ave., Hartford 14, Conn.)

1–3. Alkaline Pulping, 15th conf., Houston, Tex. (Technical Assoc. of the Pulp and Paper Industry, 360 Lexington Ave., New York 17)

1–3. Experimental Mechanics, 1st intern. congr., New York, N.Y. (Soc. for Experimental Stress Analysis, P.O. Box 168, Central Sq. Station, Cambridge 39, Mass.)

1–3. High Magnetic Fields, intern. conf., Cambridge, Mass. (H. H. Kolm, Lincoln Laboratory, Massachusetts Inst. of Technology, Lexington 73)

1–3. Transplantation, CIBA Foundation symp. (by invitation), London, England. (CIBA Foundation, 41 Portland Pl., London, W.1)

1–4. American Soc. of Tropical Medicine and Hygiene, Washington, D.C. (R. B. Hill, 3575 St. Gaudens Rd., Miami 33, Fla.)

1–4. Society of Economic Geologists, Cincinnati, Ohio. (E. N. Cameron, Science Hall, Univ. of Wisconsin, Madison 8)

2–3. Cancer Chemotherapy, clinical symp., Washington, D.C. (T. P. Waalkes, Chemotherapy Natl. Service Center, NIH, Bethesda 14, Md.)

2–4. American Soc. for Cell Biology, 1st, Chicago, Ill. (H. Swift, Dept. of Zoology, Univ. of Chicago, Chicago 37)

2–4. Geochemical Soc., Cincinnati, Ohio. (F. R. Boyd, Jr., Geophysical Laboratory, 2801 Upton St., NW, Washington 8)

2–4. Geological Soc. of America, Cincinnati, Ohio. (F. Betz, Jr., GSA, 419 W. 117 St., New York 27)

2–4. Inter-Society Cytology Council, annual, Memphis, Tenn. (P. A. Younge, 1101 Beacon St., Brookline 46, Mass.)

2–4. National Assoc. of Geology Teachers, Cincinnati, Ohio. (D. J. Gare, Principia College, Elsah, Ill.)

2–4. Paleontological Soc., Cincinnati, Ohio. (H. B. Whittington, MCZ, Harvard Univ., Cambridge 38, Mass.)

2–4. Society for Industrial and Applied Mathematics, Washington, D.C. (Chairman, Program Committee, SIAM, P.O. Box 7541, Philadelphia 1, Pa.)

2–5. Mathematical Models in the Social and Behavioral Sciences, conf., Cambria, Calif. (F. Massarik or P. Ratoosh, Mathematical Models Conf., Graduate School of Business Administration, Univ. of California, Los Angeles 24)

3–4. Central Soc. for Clinical Research, Chicago Ill. (J. F. Hammarsten, Veterans Administration Hospital, 921 N.E. 13 St., Oklahoma City 4, Okla.)

4. Society for the Scientific Study of Sex, New York, N.Y. (H. G. Beigel, 138 E. 94 St., New York 28)

5–8. American Speech and Hearing Assoc., Chicago, Ill. (K. O. Johnson, 1001 Connecticut Ave., NW, Washington 6)

5–9. Society of Exploration Geophysicists, 31st annual intern., Denver, Colo. (C. C. Campbell, Box 1536, Tulsa 1, Okla.)

5–11. Stomatology of Peru, intern. congr., Lima, Peru. (A. Rojas, Avenue Pershing 155, San Isidro, Lima)

5–15. Japanese Chemical Engineers Soc., 25th anniversary congr., Tokyo and Kyoto, Japan. (Kagaku-Kogaku Kyokai, Shunichi Uchida, 609 Kojunsha Bldg. No. 4, 6-Chome, Ginza, Chou-Ku, Tokyo)

5–18. Latin American Phytotechnical Meeting, 5th, Buenos Aires, Argentina. (U. C. Garcia, Rivadavia 1439, Buenos Aires)

6–8. Association of Military Surgeons of the U.S., 68th annual, Washington, D.C. (R. E. Bitner, AMSUS, 1726 Eye St., NW, Washington 6)

6–8. Cell in Mitosis, 1st annual symp., Detroit, Mich. (L. Levine, Dept. of Biology, Life Sciences Research Center, Wayne State Univ., Detroit 2)

6–9. Atomic Industrial Forum–9th Hot Laboratories and Equipment Conf., Chicago, Ill. (O. J. Du Temple, American Nuclear Soc., 86 E. Randolph St., Chicago)

6–9. Southern Medical Assoc., Dallas, Tex. (R. F. Butts, 2601 Highland Ave., Birmingham 5, Ala.)

8. American Acad. of Arts and Sciences, Brookline, Mass. (J. L. Oncley, 280 Newton St., Brookline 46)

8–10. Nondestructive Testing in Electri-

cal Engineering, conf., London, England. (Secretary, Institution of Electrical Engineers, London W.C.2)

8–11. Acoustical Soc. of America, Cincinnati, Ohio. (W. Waterfall, American Inst. of Physics, 335 E. 45 St., New York 17)

8–11. Institute of Management Sciences, San Francisco, Calif. (W. Smith, Inst. of Science & Technology, Univ. of Michigan, Ann Arbor)

8–11. Plasma Physics, American Physical Soc., 3rd annual, Colorado Springs, Colo. (F. Ribe, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, N.M.)

9–10. Operations Research Soc. of America, 20th, San Francisco, Calif. (P. Stillson, 115 Grove Lane, Walnut Creek, Calif.)

9–11. Gerontological Soc., Pittsburgh, Pa. (R. W. Kleemeier, Washington Univ., Skinker and Lindell, St. Louis 30, Mo.)

9–12. Pacific Coast Fertility Soc., Palm Springs, Calif. (G. Smith, 909 Hyde St., San Francisco 9, Calif.)

9–20. Photography, Cinematography, and Optics, 3rd intern. biennial, Paris, France. (Comité Francais des Expositions, 15 rue de Bellechasse, Paris 7)

12–17. Bahamas Conf. on Medical and Biological Problems in Space Flight, Nassau, Bahamas. (I. M. Wechsler, P.O. Box 1454, Nassau)

13–14. Exploding Wire Phenomenon, 2nd intern. conf., Boston, Mass. (W. G. Chace, Thermal Radiation Laboratory, CRZCM, Geophysics Research Directorate, Air Force Cambridge Research Laboratories, Bedford, Mass.)

13–16. Magnetism and Magnetic Materials, 7th annual intern. conf., Phoenix, Ariz. (P. B. Myers, Motorola, Inc., 5005 E. McDowell Rd., Phoenix 10)

13–17. American Public Health Assoc., 89th annual, New York, N.Y. (APHA, 1790 Broadway, New York)

13–17. Gulf and Caribbean Fisheries Inst., 14th annual, Miami Beach, Fla. (J. B. Higman, Marine Laboratory, Univ. of Miami, 1 Rickenbacker Causeway, Virginia Key, Miami 49)

13–18. European Conf. on the Control of Communicable Eye Diseases, Istanbul, Turkey. (World Health Organization, Palais des Nations, Geneva, Switzerland)

14–16. American Meteorological Soc., Tallahassee, Fla. (Executive Secretary, AMS, 45 Beacon St., Boston 8, Mass.)

14–17. Corrosion in Nuclear Technology, symp., Paris, France. (European Federation of Corrosion, Société de Chimie Industrielle, 28 rue St. Dominique, Paris 7°)

14–18. Puerto Rico Medical Assoc., Santurce. (J. A. Sanchez, P.O. Box 9111, Santurce)

15–17. Eastern Analytical Symp., New York, N.Y. (A. Rekus, EAS, Research Dept., Baltimore Gas & Electric Co., Pratt St., Baltimore, Md.)

15–18. Society of Naval Architects and Marine Engineers, annual, New York, N.Y. (W. N. Landers, SNAME, 74 Trinity Pl., New York 6)

16–18. American Psychiatric Assoc., Milwaukee, Wis. (J. D. McGucken, 756 N. Milwaukee St., Milwaukee 2)

16–18. Etiology of Myocardial Infarction, intern. symp. (by invitation), Detroit, Mich. (T. N. James, Section on Cardiovascular Research, Henry Ford Hospital, Detroit)

16–18. Southern Thoracic Surgical Assoc., Memphis, Tenn. (H. H. Seiler, 517 Bayshore, Blvd., Tampa 6, Fla.)

16–19. American Anthropological Assoc., Philadelphia, Pa. (S. T. Boggs, 1530 P St., NW, Washington, D.C.)

17–18. Southern Soc. for Pediatric Research, Atlanta, Ga. (W. G. Thurman, Dept. of Pediatrics, Emory Univ. School of Medicine, Atlanta)

17–31. National Soc. for Crippled Children and Adults, annual conv., Denver, Colo. (NSCCA, 2023 W. Ogden Ave., Chicago 12, Ill.)

19–22. International College of Surgeons, Western regional, San Francisco, Calif. (W. F. James, 1516 Lake Shore Drive, Chicago 10, Ill.)

22–27. Automation and Instrumentation, 5th conf., Milan, Italy. (Federezione delle Societa Scientifiche e Techniche di Milano, via S. Tomaso 3, Milan)

22–1. Radioisotopes in Animal Biology and the Medical Sciences, conf., Mexico City, D.F. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria)

23–25. Central Assoc. of Science and Mathematics Teachers, Chicago, Ill. (J. Kennedy, Indiana State Teachers College, Terre Haute)

24–25. American Soc. of Animal Production, Chicago, Ill. (C. E. Terrill, Animal Husbandry Research Div., U.S. Dept. of Agriculture, Beltsville, Md.)

(See issue of 15 September for comprehensive list)

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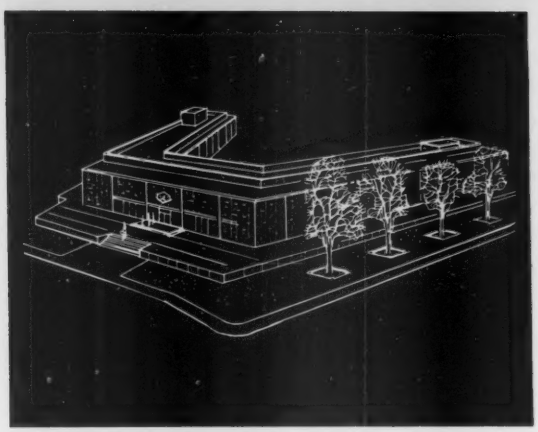

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First, there must exist a corporate philosophy that prompts bold, imaginative research and insures that the individual contributor is recognized and rewarded. Secondly, there must be the freedom that encourages frequent and continuing interdisciplinary exchange. Above all, there must be men--scientists who combine enthusiasm with true professional competence and who are interested in teaching as well as learning.

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STAFF RESEARCH IMMUNOLOGIST

Will be responsible for staffing and leading a group of immunologists in a research program leading towards applications in the diagnosis and treatment of diseases. Must have a Ph.D. and/or M.D. degree and several years' experience.

RESEARCH CHEMIST

To carry out synthetic organic chemistry studies to provide new compounds of potential therapeutic interest. Must have Ph.D. degree and a minimum of 1-2 years' synthetic organic chemistry experience.

RESEARCH PHARMACOLOGIST

Will supervise administration of new drugs to animals for determination of acute LD 50's and to observe gross pharmacological effects. Additional responsibilities will include carrying out chronic toxicological studies on new compounds of interest. Must possess a Ph.D. degree and previous toxicological experience.

RESEARCH BIOCHEMIST

To carry out studies on metabolic effect and fate of new drugs. Applicants should possess a recent Ph.D. degree and some experience in drug metabolism research.

RESEARCH BIOCHEMIST

Will be responsible for organizing and conducting a research program in protein chemistry, enzyme chemistry, metabolic chemistry, analytical biochemistry, or physical biochemistry. Should possess Ph.D. in biochemistry, microbiology or biology plus previous hospital or pharmaceutical research experience.

ASSISTANT RESEARCH PHARMACOLOGIST

To conduct studies in screening new drugs and assisting in complete pharmacological evaluation. Should possess a B.S. in pre med with graduate work in physiology or pharmacology.

ASSISTANT RESEARCH BIOCHEMIST

Will be responsible for carrying out clinical chemical investigations in connection with laboratory evaluations of new drugs. Should possess a B.S. in chemistry or biology plus experience as a medical technologist.

Inquiries May Be Addressed In Complete Confidence To:
Dr. R. A. McCracken (Personal discussions can be arranged at your convenience, including Saturdays, in Elkhart, Indiana)

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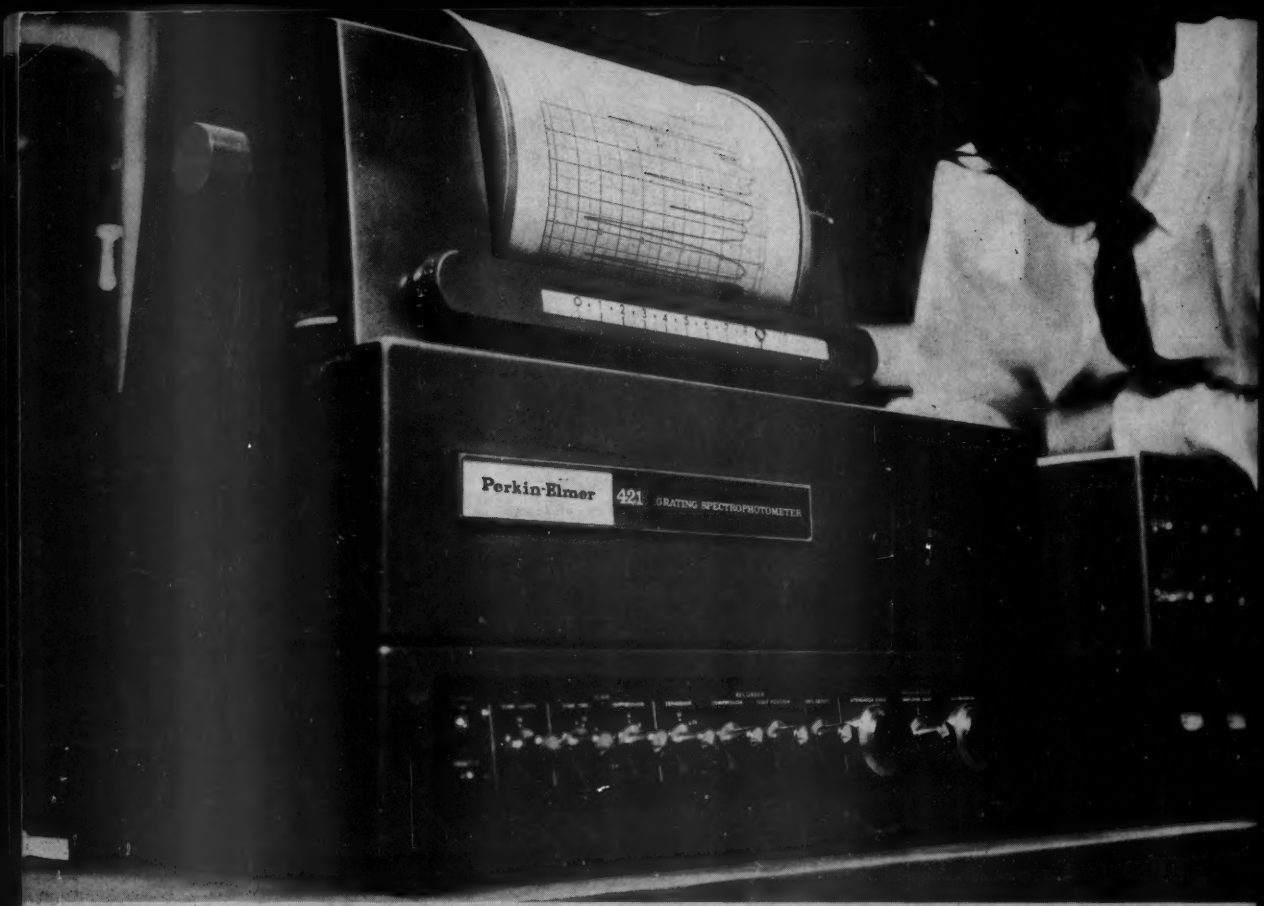
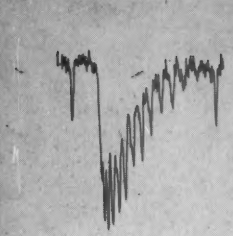
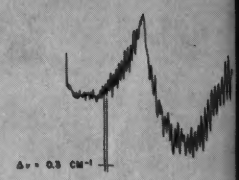




NH_3 between 970 and 920 wavenumbers.

Indene from 3500 to 530 wavenumbers.



CS_2 between 2200 and 2165 wavenumbe

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